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SEEDLINGS

VOL. I.

A

CONTRIBUTION TO OUR KNOWLEDGE

OF

SEEDLINGS

BY THE RIGHT HON.

SIR JOHN LUBBOCK, BART.

M.P., F.R.S., D.C.L., LL.D.

WITH 684 FIGURES IN TEXT

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IN TWO VOLUMES

VOL. I.

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1892

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TO

SIR JOSEPH HOOKER

BY WHOSE RESEARCHES

BOTANICAL SCIENCE HAS BEEN SO GREATLY ENRICHED

AND TO WHOSE FRIENDSHIP

I OWE SO MUCH

PREFACE

The germination of plants is certainly not the least interesting portion of their life-history, but it has not as yet attracted the attention it deserves. The forms of cotyledons, and the fact that they differ so much from the subsequent leaves, had of course been alluded to more or less fully in botanical works, but no explanation had been offered, and Klebs[1] in a recent memoir expressly states that the problem is still an enigma.

Under these circumstances it seemed to me that the subject was very promising, and it was evident that Kew would afford unrivalled opportunities for such an investigation. I applied, therefore, to Sir Joseph Hooker, and I cannot too cordially thank him, as well as his successor, Mr. Thiselton Dyer, and indeed the whole of the staff, for the facilities they have offered me, and for their valuable assistance in many ways.

I have also to thank Mr. Carruthers and the Trustees of the British Museum, Mr. Lynch and the authorities of the Cambridge Botanic Gardens, and other friends, especially Mr. Hanbury, for the gift or loan of many rare or interesting specimens. By degrees a large store of material accumulated, which I made use of for several papers which the Linnean Society has done me the honour of publishing in their Journal. I thought, however, that it would be well to publish descriptions and figures of the more interesting species, especially as many of them are not often grown from seed, and are therefore not easily procurable.

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[1] *Beitr. zur Morphologie u. Biologie der Keimung*: 'Im Allgemeinen sind uns diese Verschiedenheiten in den Blattformen hinsichtlich ihrer biologischen Bedeutung für die Pflanze ein Räthsel.'—*Untersuch. Bot. Instit. zu Tübingen* 1 84.

The seedlings were drawn in most cases either by Mr. HENRY, or by my assistant, Mr. FRASER, to whose skill and ability I am greatly indebted. In the classification, etc., I have followed BENTHAM and HOOKER's great work, the 'Genera Plantarum.' My time has latterly been so much occupied with other matters that Mr. RENDLE has been good enough to see the book through the press. Sir JOSEPH HOOKER has also most kindly looked through the proofs, and made many valuable suggestions, for which I beg to offer him my very warm thanks.

HIGH ELMS, DOWN, KENT.

A CONTRIBUTION

TO OUR

KNOWLEDGE OF SEEDLINGS

INTRODUCTION.[1]

Forms of Leaves.

I have elsewhere[2] called attention to the forms of leaves, and discussed the causes to which we may ascribe the endless differences which they present. Vertical leaves, for instance, are generally long and narrow, horizontal ones have a tendency towards width, which brings the centre of gravity nearer to the point of support. Wide leaves, again, are sometimes heart-shaped, sometimes palmate. The former shape is obviously that which would arise if a linear leaf were gradually widened at the base; and I have pointed out that in many species with palmate leaves—for instance, species of Passiflora, Cephalandra, Hibiscus, &c.—the first, or few first, leaves are entire and more or less cordate. The cordate form, then, appears to be the early, the palmate a later form. But how has the palmate form arisen?

The origin is perhaps connected with the manner in which the leaves are folded up, more or less like a fan, into the bud, so as to save space.

Another advantage perhaps is that in cordate leaves with veins following the curvature of the leaf—as, for instance, in Tamus (fig. 1)—the vascular bundles pursue necessarily a curved course; while in palmate leaves, as in Acer (fig. 2), the veins are straight; and it is clearly an advantage that the main channels which convey the nutritive fluid should hold a direct course. In such cases the leaf naturally assumes the lobed form with a vein running to the point of each lobe. There has indeed been some question whether the path of the sap lies mainly in the cell-walls or in the cell-cavities; but the evidence seems to point strongly to the latter view.[1] The tracheids of, say, the Yew 'are at least seventy or eighty times as long as they are broad, so that in travelling transversely the length of a single tracheid the water-current has to traverse seventy cell-walls instead of one.'[2]

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[1] This Introduction is taken from the *Journal of the Linnean Society* (*Botany*), vol. xxii. and vol. xxiv.

[2] *Flowers, Fruits, and Leaves* (Nature Series), Macmillan & Co. See also various papers in the *Journal of the Linnean Society*.

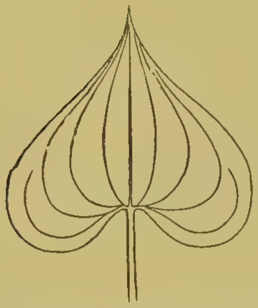

Fig. 1.—Leaf of *Tamus*, to show the curved course of the veins.

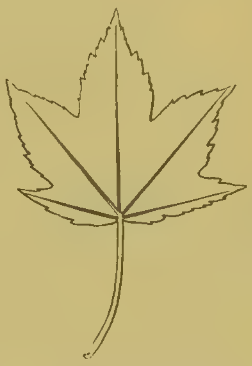

Fig. 2.—Leaf of Sycamore, to show the straight course of the veins.

In reply, then, to the question why some plants should have cordate leaves with curved veins, while others have palmate leaves with straight ones, I suggested that the first retains the old form of leaf, while the latter has assumed one which presents certain advantages.

In my book on Flowers, Fruits, and Leaves, I have also given some account of the causes which have determined the form and structure of seeds and fruits.

These considerations naturally led me to the study of cotyledons.

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[1] See for instance Darwin and Phillips, 'On the Transpiration Stream in Cut Branches,' *Proc. Cambridge Phil. Soc.* vol. v.

[2] *Loc. cit.* p. 364.

No one who has ever looked at seedlings can fail to have been struck by the contrast which the cotyledons afford, not only to the final leaves, but even to those by which they are immediately followed.

Let us then take certain plants (especially, as far as possible, the commonest and most familiar), and see what light can be thrown on the varied forms which their seedlings present. Look, for instance, at the familiar Mustard and Cress; the first (fig. 3) has kidney-shaped cotyledons, one of them rather larger than the other: while the Cress (*Lepidium sativum*) (fig. 4), on the other hand, has the cotyledons divided into three lobes. The Pink (*Dianthus*) (fig. 22) has broad cotyledons, the Chickweed (*Cerastium*) (fig. 23) narrow ones; those of the Beech (fig. 13) are fan-shaped in outline; those of the Sycamore (fig. 9) shaped almost like a knife-blade; those of Eschscholtzia (fig. 40) divided like a hay-fork; those of the Bean or Acorn thick and fleshy.

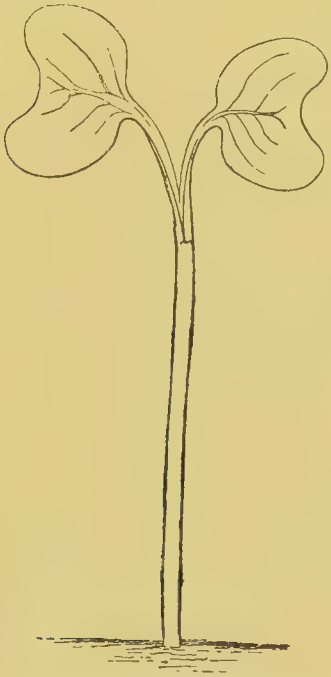

Fig. 3.—Seedling of Mustard (*Brassica nigra*), × 3.

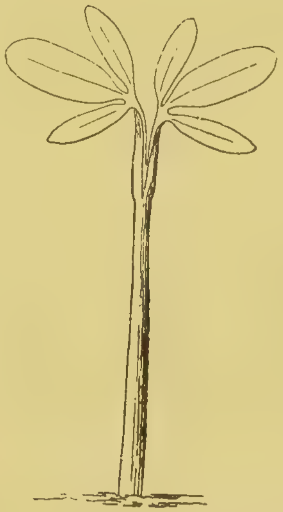

Fig. 4.—Seedling of Cress (*Lepidium sativum*), × 3.

Mustard and Cress were the delight and wonder of our childhood; but at that time it never occurred, to me at least, to ask why they were formed as they are, and why they differed so much. So they grew, and beyond that it did not occur to me, nor I think to most, that it was possible to inquire.

I now propose, however, to suggest reasons which may account for some, at any rate, of these differences.

In previous memoirs I have discussed the causes which regulate the forms of seeds, and will not now therefore enter into them. I may, however, observe that the shape of the cotyledons seems to have little, if any, influence on that of the seed.

OVULE AND SEED.

The seed of a flowering-plant contains a more or less highly developed embryo, which, after a certain time, will, under favourable conditions, resume growth, emerging from the seed-coat to produce the young plant or seedling. In the section of flowering-plants known as Gymnosperms, and including the Conifers and Cycads, the seeds are borne naked on an open scale, while in the far larger section of the Angiosperms they are protected till ready for dispersion in the closed cavity of the *Fruit.*

The seed is the result of the fertilisation of the ovule by the pollen. The effect of fertilisation, however, extends beyond the ovules to the ovary in which they are contained, causing often immense increase in size, as well as important structural changes. The ovary thus becomes the fruit as the ovule has become the seed.

Sometimes the effect extends still further to other parts of the flower, which thus persist, usually with increased size or change of structure, and form part of what is then termed a pseudocarp or false fruit. In the apple, for instance, the edible portion consists of the greatly developed floral-receptacle, which includes the ovary as its core. The ovules are borne usually on some definite part of the ovary wall or walls known as the placenta. They consist of an internal portion, the *nucellus*, one cell of which grows at the expense of the rest to form an *embryo-sac*, which again contains the egg-cell or *oosphere*, and one or two integuments entirely surrounding it except at the apex, where a small aperture, known as the *micropyle*, is left. In the process of fertilisation the pollen-tube passes down the micropyle to the oosphere which, enclosed in the embryo-sac, approaches very close to the outer wall of the ovule at this point. After fertilisation the oosphere develops into the embryo, the rest of the embryo-sac becoming filled with a cellular tissue, the *endosperm*, containing a store of food for the young plant. This is, however, sometimes re-absorbed before germination, so that the embryo occupies the whole interior of the mature seed. The original substance of the ovule, the nucellus, is often completely displaced by the embryo-sac, and the subsequent development of endosperm in its interior. One or two layers, however, may persist and share with the integuments in the formation of the seed-coats. Occasionally, as occurs in the Nymphæaceæ, Piperaceæ, and some of the Scitamineæ, a considerable portion of the nucellus remains in the mature seed, sharing with the endosperm the function of storing reserve material, or it may quite take the place of the endosperm.

There is considerable variety in the position and arrangement of parts of the ovule and subsequently of the seed. They are attached to the placenta by a stalk or *funicle*, the point of connection with the funicle being called the *hilum*. Vascular tissue supplying nutriment runs up the funicle into the integuments, and the point reached before the nutritive vessels ramify is the *chalaza*.

In some cases usually where there is only one ovule in the ovary or ovary-cell, as *e.g.* in Buckwheat or Nettle, the ovule stands erect, and the micropyle is opposite the hilum, which in this case coincides with the chalaza. The ovule is then said to be *orthotropous*[1] or straight. But this, though the simplest, is the least common form of seed. More often, as in the Bean, Chickweed, and many others, the ovule during its growth is curved on itself, so that the apex and the micropyle are brought down very near to the base. Such ovules are known as *campylotropous* or curved.

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[1] Figures of the various positions of the ovule are given in various text-books; see, for instance, Prantl and Vines' *Text-book on Botany*, ed. 4, p. 173 fig. 130; or Asa Gray's *Structural Botany*, p. 278.

In a third category the ovule itself is straight, but it stands as it were at right angles to the base of attachment. These are called *half-anatropous* or half-reversed.

Lastly, in a very large number—in fact the largest—the ovule is quite inverted on its base; the funicle, or stalk, growing with its curvature, and forming a sort of ridge or *raphe*, which is very conspicuous in the ovule, but gradually becomes less and less apparent, finally becoming merged in the seed-coat. The chalaza is thus carried right away from the hilum to the opposite end, and the whole ovule or seed is reversed, so that the true base is removed from, and the true apex brought close to, the point of union with the ovary. Such are called *anatropous* or reversed.

Now this seems a very curious and roundabout arrangement. It is described in all works on general Botany, but those which I have seen do not give any explanation of its object or purpose. I will for the moment omit any consideration of campylotropous and half-anatropous seeds, and confine myself to orthotropous and anatropous forms.

In most orthotropous species, as for instance in the Buckwheat, the ovule is straight, upright, and attached by its base to the funicle and base of the ovary. At the free end is the micropyle, and immediately below it the egg-cell, which, when fertilised by the pollen, becomes the rudiment or embryo of the future plant. When the pollen falls on the stigma it soon pushes out a little tube, which rapidly elongates, passes into the cavity of the ovary, and entering the micropyle of the ovule fertilises it.

But ovules thus constituted are, as I have already mentioned, exceptional. In a great many plants the ovule, instead of being upright and attached to the base of the ovary, is, on the contrary, attached to the summit and pendent. Now in a pendent orthotropous ovule the micropyle is turned away from the pollen-tube, and the object and effect of the ovule being reversed or anatropous is to bring it back into a convenient position for fertilisation. So also, when there are many ovules, the result of the anatropous arrangement is again to bring the micropyle into a suitable position.

The structure and arrangement of the ovule have been the subject of various important memoirs, which, however, have been almost exclusively descriptive. Dalmer[1] indeed quotes Schleiden, who, speaking of Berberis, pointed out that among the normal anatropous ovules here and there one occurs which is orthotropous, and that these never develop into seeds ('Die Befruchtung der Ovule scheint mir aber in ganz bestimmter Beziehung zu dem vorgeschriebenen Lauf der Pollenschläuche zu stehen, denn stets beobachtete ich, dass diese regelwidrige atropen Eichen unbefruchtet blieben'). The pollen-tubes, however, would naturally follow the regular course; and we could not, I think, deduce a general conclusion from such rare and abnormal cases. Dalmer himself does not seem to have done so; for, after referring to the different forms of ovules, he observes that '*sometimes* the form of the ovule appears to be adapted so as to facilitate the entrance of the pollen-tube' ('scheint zuweilen die Gestalt des Ovulums dem Eintritt des Pollenschlauches angepasst zu sein'). Even here, then, the explanation I venture to suggest seems referred to rather as an exceptional occurrence than as a general explanation of this remarkable arrangement. It must be admitted that there are some cases in which the anatropy of the ovule appears at first sight rather disadvantageous than otherwise. Most of these can, I believe, be explained, while in some it is possible that the plants retain, even perhaps to their present disadvantage, an arrangement inherited from an ancestral condition in which it was beneficial. I hope, however, to enter into this question more fully on a future occasion.

The mature seed contains the more or less differentiated embryo, in some cases, as in Larkspur (*Delphinium*) (fig. 104), very small, consisting only of a small basal portion the radicle, which on germination gives rise to the primary root, and one (Monocotyledons), two (Dicotyledons), or several (Conifers) seed-leaves or cotyledons, sheathing a microscopic plumule—from which the future stem is developed. The rest of the space is occupied by the mealy, oily, fleshy, or horny endosperm. In other cases, as in the Ash (*Fraxinus*) (fig. 46) or Castor Oil (*Ricinus*) (fig. 52), the embryo is much larger, and we find a little miniature plant, generally white, sometimes green, but still embedded in endosperm. In others, again, the endosperm is reduced almost to a film, as in Hippophaë (fig. 53), and finally, as in the Bean (fig. 51), the embryo occupies the whole seed, and the nourishment intended for the young plant is stored up in the cotyledons themselves. Similarly, in a Walnut, the two halves of the seed are filled by the two cotyledons, and attached to them may be found the little plantlet with a delicate white radicle, and a little plumule bearing five or six minute rudiments of leaves, often just tipped with green.

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[1] 'Ueber die Leitung der Pollenschläuche bei den Angiospermen,' *Jenaisch Zeits.* 1880, p. 530.

The Bean and Walnut are instances of *exalbuminous* or non-endospermic seeds, while those containing endosperm (or perisperm) are termed *albuminous*. The seed-coat is double in cases where the ovule was provided with two integuments, the outer coat, or *testa*, developed from the outer integument, being the stronger and often crustaceous in texture. The inner coat or *tegmen* is thin or soft and delicate, conforming closely to the surface of the endosperm or embryo. It is developed chiefly from the inner integument of the ovule, and is therefore wanting in ovules with only one coat.

The testa is often provided with appendages or outgrowths of very diverse form and nature, but generally having reference to dissemination of the seed, as in the case of wings or tufts of hair. A more or less incomplete accessory seed-coat is sometimes formed between the time of fertilisation and ripening of the seed. This is known as an *aril*. Good instances are seen in the Water Lily (*Nymphæa*) and the Yew. Crest-like or wart-shaped appendages developed during the same period are known as *strophioles* or *caruncles*. The Castor Oil (*Ricinus*) supplies a good instance of the latter.

FORMS OF COTYLEDONS.

I will now pass from seeds to seedlings. No one who has ever looked at young plants can have failed to be struck by the contrast they afford to the older specimens belonging to the same species. This arises partly from differences in the leaves, partly from the contrast which the cotyledons, or seed-leaves, afford, not only to the final leaves, but even to those by which they are immediately followed.

This contrast between the cotyledons and true leaves is so great that one might almost be pardoned for asking whether they can be brought into actual correlation.

So far, indeed, are the cotyledons from agreeing with the forms of the leaves, that the difficulty is to find any which have been clearly influenced by them. One species of Ipomœa (*I. Pes-capræ*) has both cotyledons and leaves, as the name denotes, somewhat like the foot of a goat; but the leaves vary considerably, and it is probable that the resemblance may be accidental. A clear case is, however, afforded by the Onagrarieæ, where in Œnothera and some allied genera the form of the mature cotyledons is evidently related to the leaves. Even here, however, the resemblance is confined to a basal portion of the cotyledon which makes its appearance subsequent to germination, and no trace of it is shown in the cotyledons themselves when they first appear.

The forms of the cotyledons in many species have been the subject of special memoirs by Tittmann, Irmisch, Wichura, Winkler, Tscherning, and other botanists; but they have not given any reasons for the various forms assumed.

Klebs, indeed, one of the most recent writers on the subject, in his interesting Memoir on Germination,[1] refers to this diversity of form, and expressly says that these differences are an enigma ('Sind gewiss diese Verschiedenheiten in den Blattformen hinsichtlich ihrer biologischen Bedeutung für die Pflanze ein Räthsel'). He observes, however, that on the whole the forms of cotyledons are much simpler than those of leaves, and he suggests that while in some cases perhaps, like the first leaves, they retain the form which characterised the species in bygone ages, we may rather, as a more generally applicable explanation, apply to them the suggestion of Goebel with reference to stipules, and regard them as simplified by arrest.[2] Another suggestion has been that cotyledons are 'a survival of the universal foliage of deciduous trees in olden geological days, ere time had differentiated them into their present varied forms.' Even, however, if this suggestion were the real explanation of the comparative simplicity, it would throw no light on the differences between the cotyledons of different species.

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[1] 'Beiträge zur Morphologie und Biologie der Keimung,' *Untersuch. Botan. Inst. v. Tübingen*, 1884 (Band i. p. 536).

[2] *Loc. cit.* p. 613.

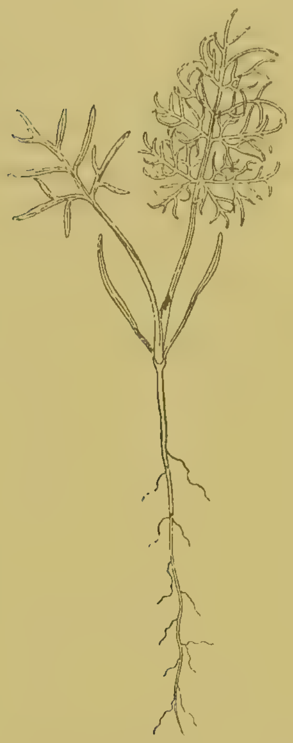

Fig. 5.—Seedling of *Fœniculum vulgare.* Half nat. size.

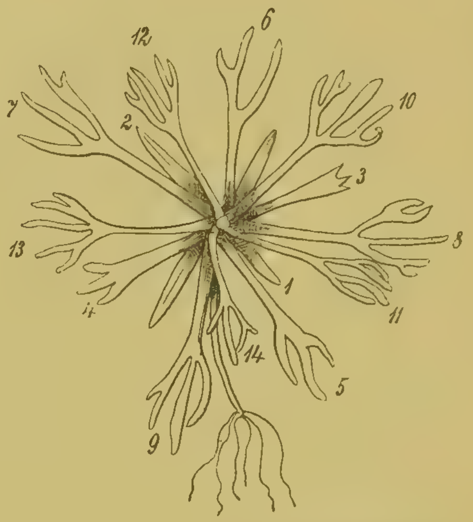

Fig. 7.—Seedling of *Ceratocephalus falcatus.* Nat. size. The numerals indicate the successive leaves.

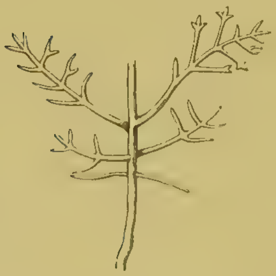

Fig. 6.—Seedling of *Coreopsis filifolia.* Half nat. size.

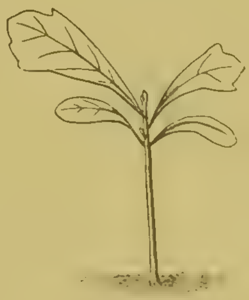

Fig. 8.—Seedling of *Platanus.* Nat. size.

Though cotyledons do not present nearly such extensive variations as leaves, still they do differ considerably from one another.

Some are narrow, in illustration of which I may refer to

Fœniculum (fig. 5), Coreopsis (fig. 6), Ceratocephalus (fig. 7), and Ferula (in the hollow stalk, or ferule, of which Prometheus brought down fire from heaven), &c., where the ultimate leaves are much divided ; Platanus (fig. 8) and Acer (fig. 9), where the ultimate leaves are palmate; and Chenopodium (fig. 10), where they are more or less triangular.

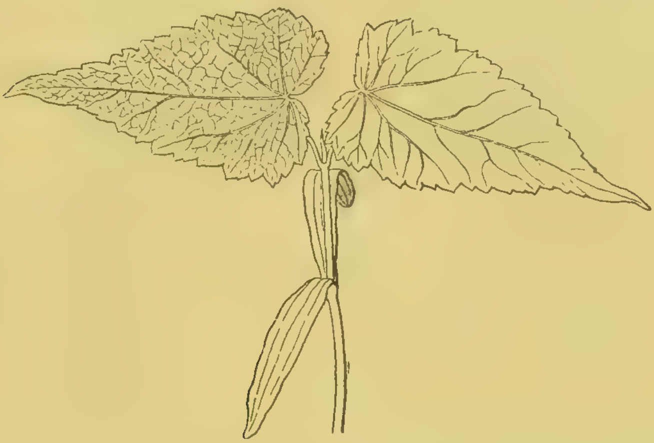

Fig. 9.—Seedling of *Acer Pseudo-Platanus*. Half nat. size.
(In this and some other figures, one (or more) of the leaves is given in outline only.)

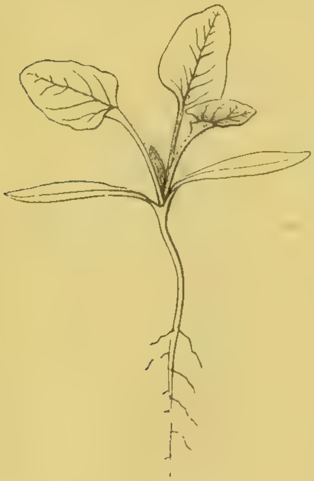

Fig. 10.—Seedling of *Chenopodium Bonus-Henricus*. Nat. size.

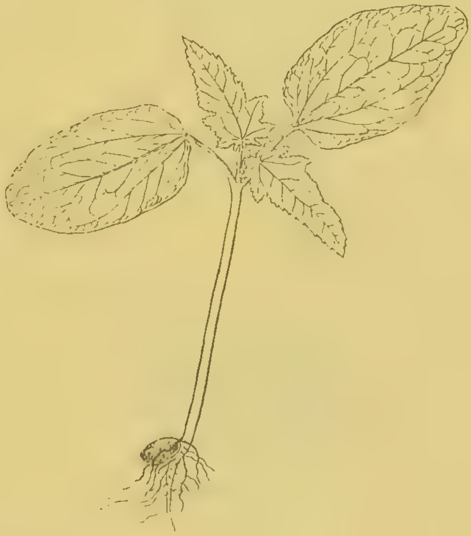

Fig. 11.—Seedling of *Ricinus sanguineus* One fourth nat. size.

Some cotyledons are broad, in illustration of which I give figures of Ricinus (fig. 11), Impatiens (fig. 12), Beech (*Fagus*) (fig. 13), Brassica (fig. 3), Hippophaë (fig. 14), Rivina (fig. 15),

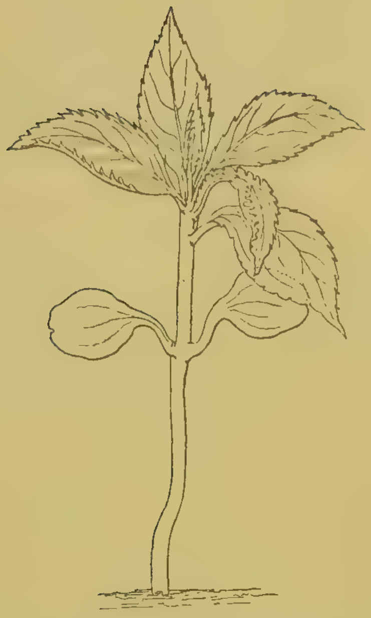

FIG. 12.—Seedling of *Impatiens balsamina*. Half nat. size.

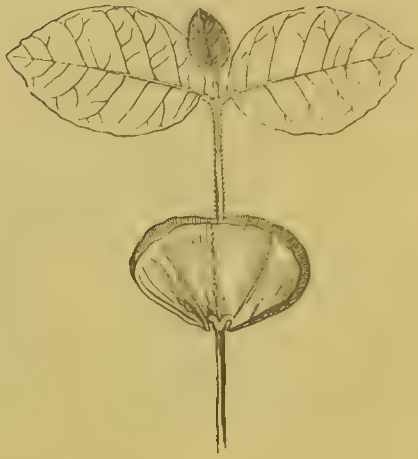

FIG. 13.—Seedling of Beech (*Fagus sylvatica*). Half nat. size.

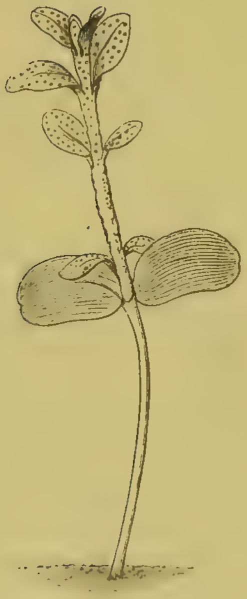

FIG. 14.—Seedling of *Hippophaë rhamnoides*. Half nat. size.

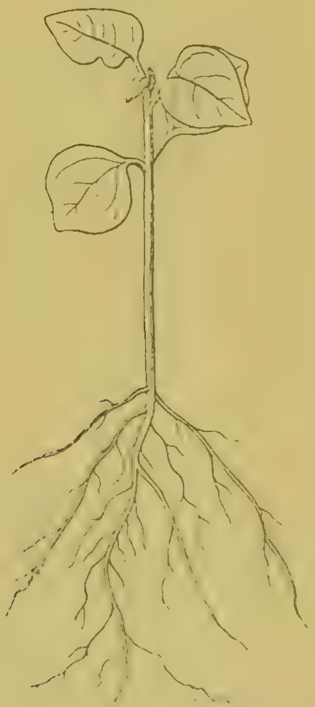

FIG. 15.—Seedling of *Rivina lævis*. Nat. size.

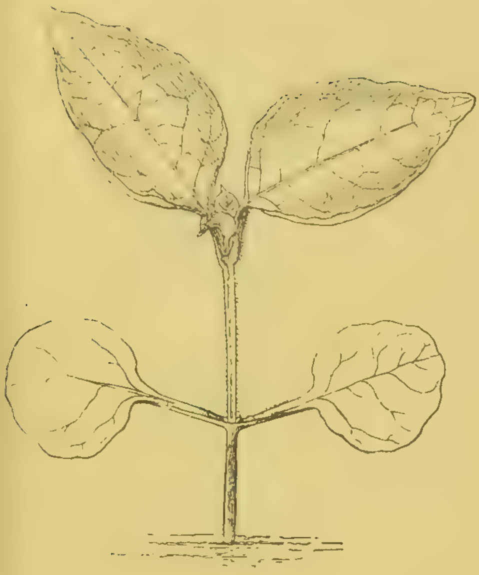

FIG. 16.—Seedling of *Asystasia coromandeliana*. Half nat. size.

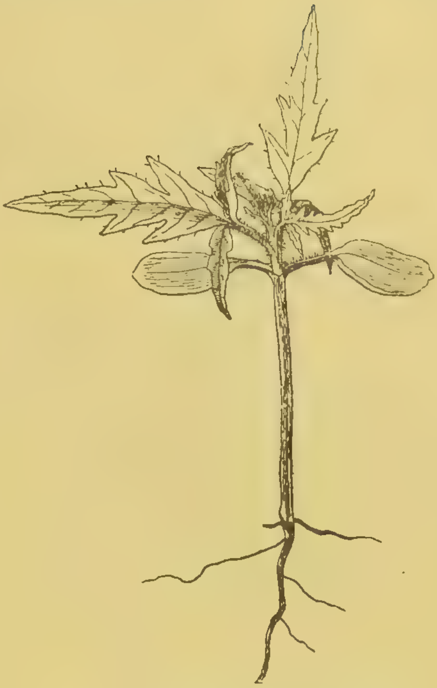

FIG. 17.—Seedling of *Rhus typhina*. Half nat. size.

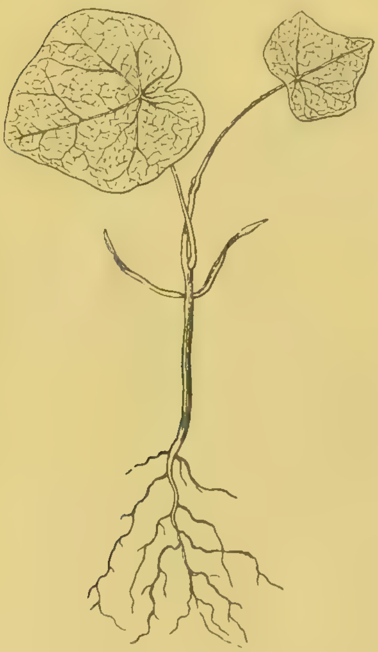

FIG. 18.—Seedling of *Menispermum canadense*. Half nat. size.

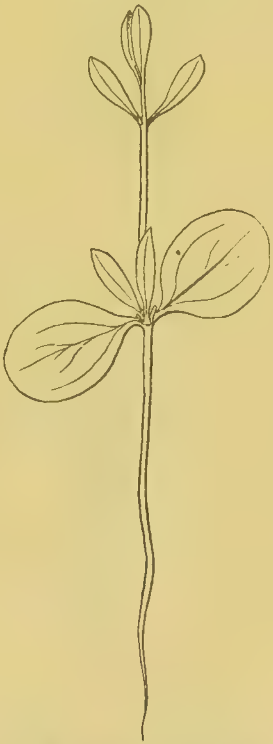

FIG. 19.—Seedling of *Linum monogynum*. Nat. size.

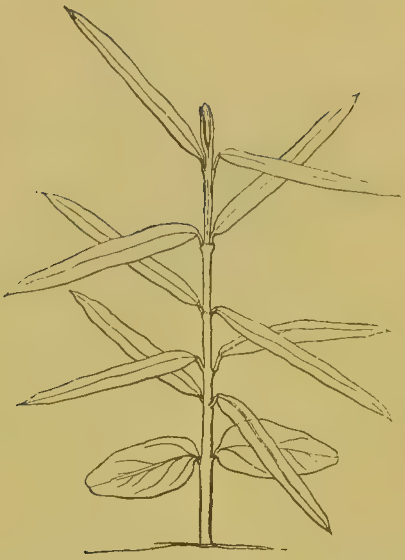

FIG. 20.—Seedling of *Olea cuspidata.* Two-thirds nat. size.

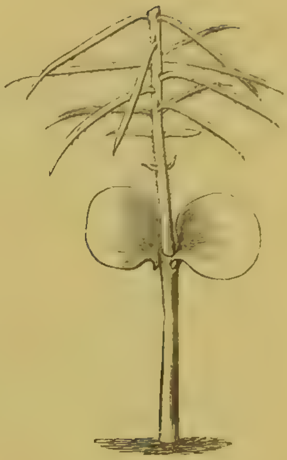

FIG. 21.—Seedling of *Hakea acicularis.* Half nat. size.

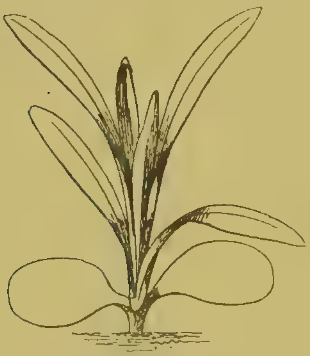

FIG. 22.—Seedling of Pink (*Dianthus Caryophyllus*). Nat. size.

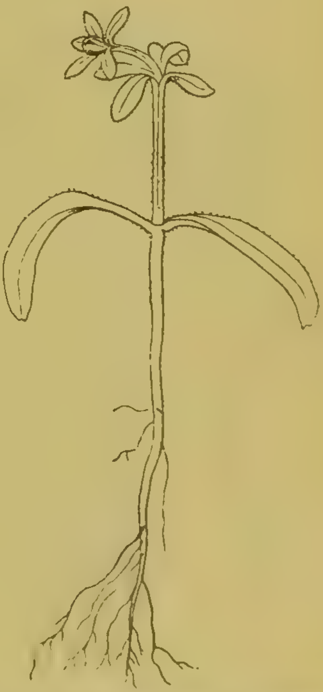

FIG. 24.—Seedling of *Galium saccharatum.* Nat. size.

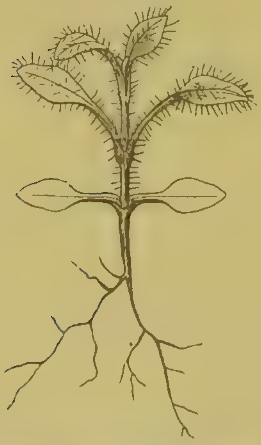

FIG. 23.—Seedling of *Cerastium arvense.* Half nat. size.

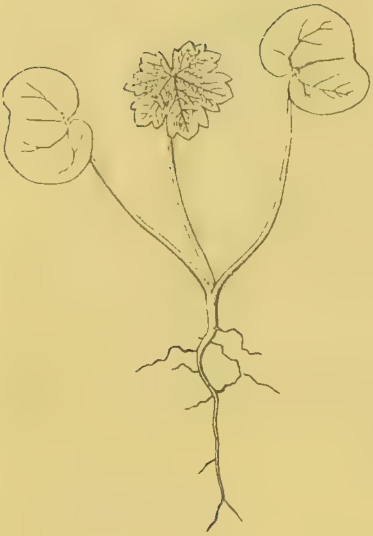

FIG. 25.—Seedling of *Geranium sanguineum.* Nat. size.

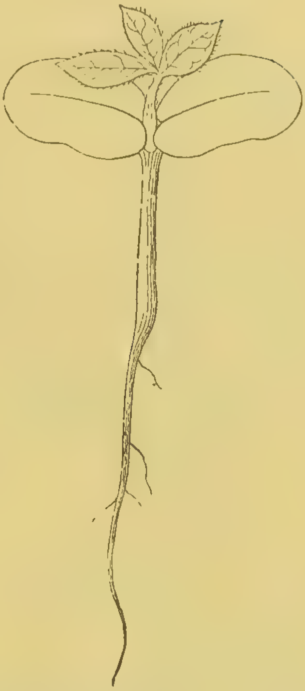

FIG. 26.—Seedling of Laburnum (*Laburnum vulgare*). Nat. size.

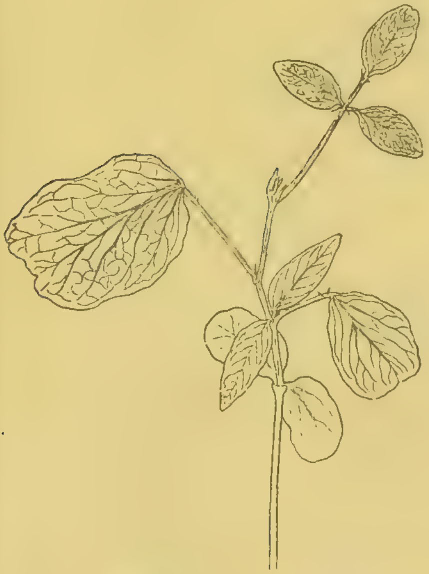

FIG. 27.—Seedling of *Clitoria Ternatea.* Half nat. size.

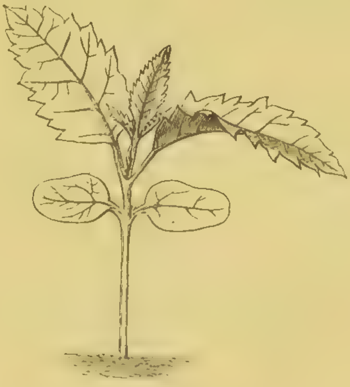

FIG. 28.—Seedling of *Schinus terebinthifolia.* Two-thirds nat. size.

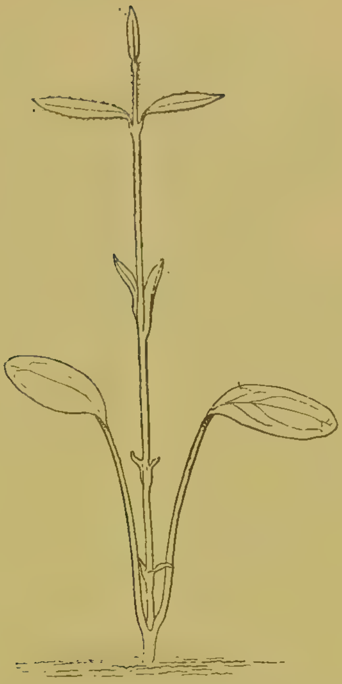

Fig. 29.—Seedling of *Microloma*, × 1½.

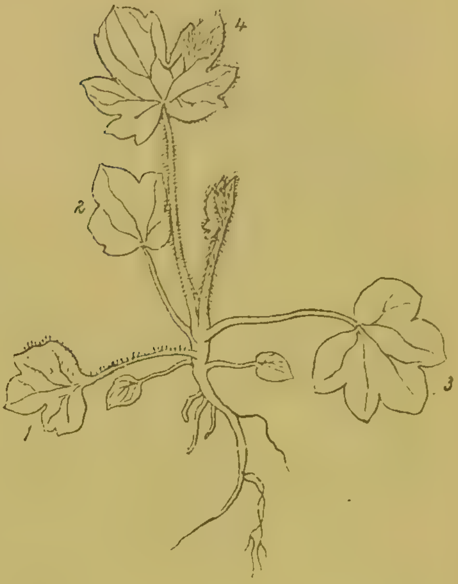

Fig. 30.—Seedling of *Delphinium elatum*. Two-thirds nat. size.

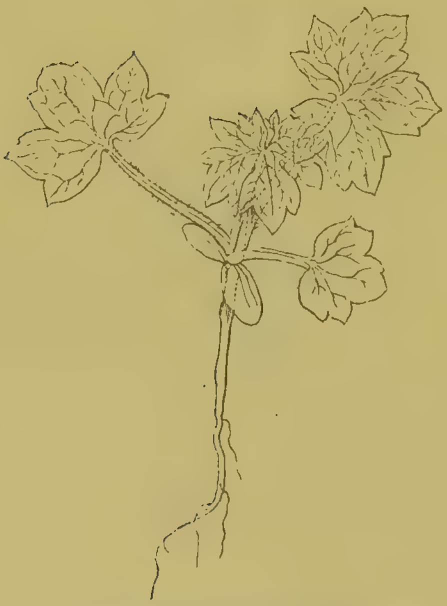

Fig. 31.—Seedling of *Delphinium Staphysagria*. Half nat. size.

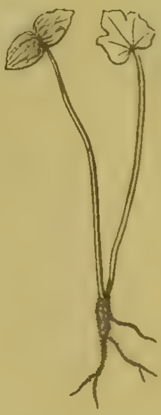

Fig. 32.—Seedling of *Delphinium nudicaule*. Half nat. size.

Asystasia[1] (fig. 16), Rhus typhina (fig. 17), and Flax (*Linum*) (fig. 19). We find some species with narrow cotyledons and broad leaves, as Menispermum (fig. 18), while in others the cotyledons are broad and the leaves narrow, as in an Australian Flax (*Linum monogynum*) (fig. 19), Hakea (fig. 21), and the Pink (*Dianthus*) (fig. 22), &c.

In some cases we find instances of broad and narrow cotyledons in the same family, as in Chickweed (fig. 23) and Pink (fig. 22), belonging to the Caryophyllaceæ; sometimes even in the same genus, as Gallium saccharatum (fig. 24) and Galium Aparine (figs. 91 and 92).

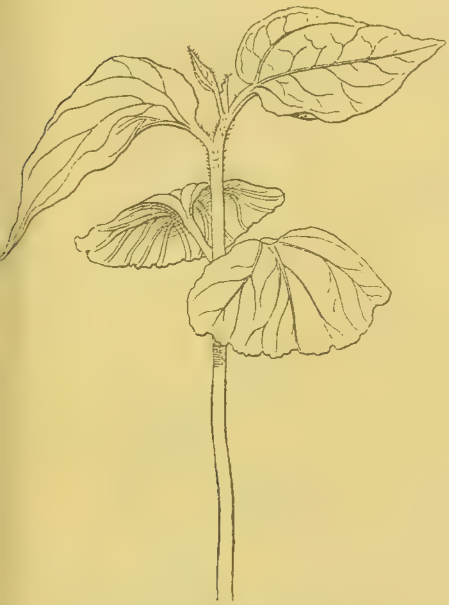

Fig. 33.—Seedling of *Cordia subcordata*. Half nat. size.

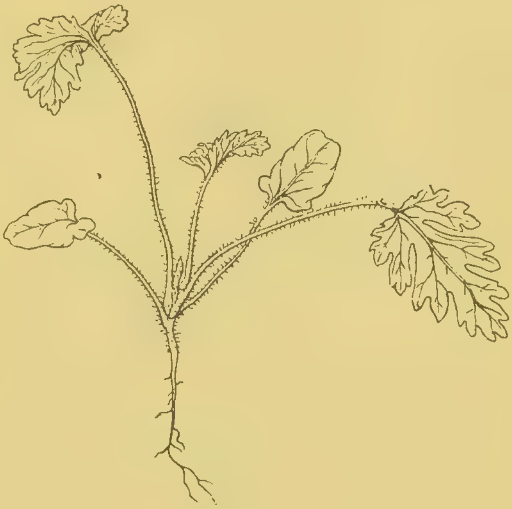

Fig. 34.—Seedling of *Pelargonium australe*. Half nat. size.

In some cases the two cotyledons are unequal, as in the Mustard (fig. 3), Cabbage, Radish, Cereus (fig. 63), Pachira,[2] &c.: in some the two halves of each cotyledon are unequal, as in the Geranium (fig. 25); or they are otherwise unsymmetrical, as in the Lupine, Laburnum (fig. 26), Clitoria (fig. 27), Schinus (fig. 28). Sometimes they are sessile, as Acer (fig. 9), Hakea (fig. 21), Laburnum (fig. 26), &c.; sometimes

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[1] In Asystasia coromandeliana there is an interesting peculiarity. The first pair of leaves of each branch, or at any rate of the lower branches, approximate to the form of the cotyledons.

[2] As described by Mr. Lynch (*Journ. Linn. Soc.* vol. xvii. p. 147).

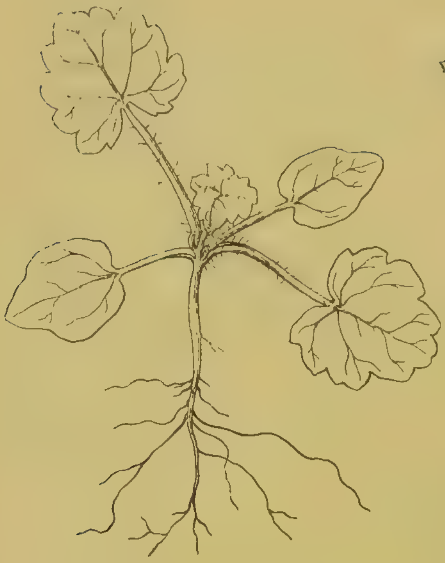

Fig. 35.—Seedling of *Malva moschata*. Nat. size.

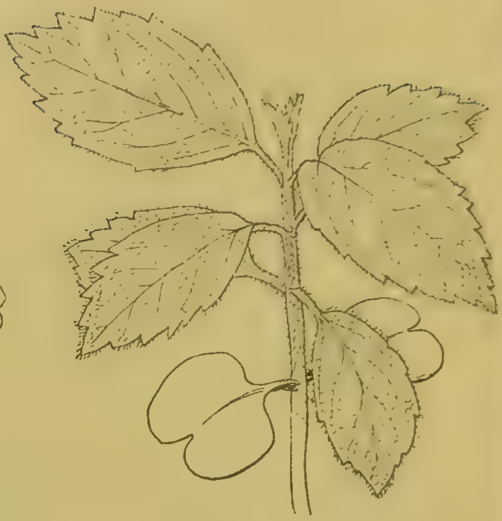

Fig. 36.—Seedling of *Spathodea campanulata*. Nat. size.

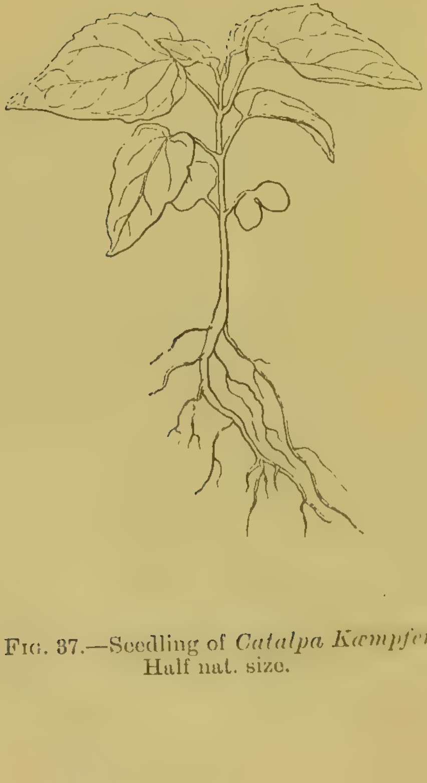

Fig. 37.—Seedling of *Catalpa Kæmpferi*. Half nat. size.

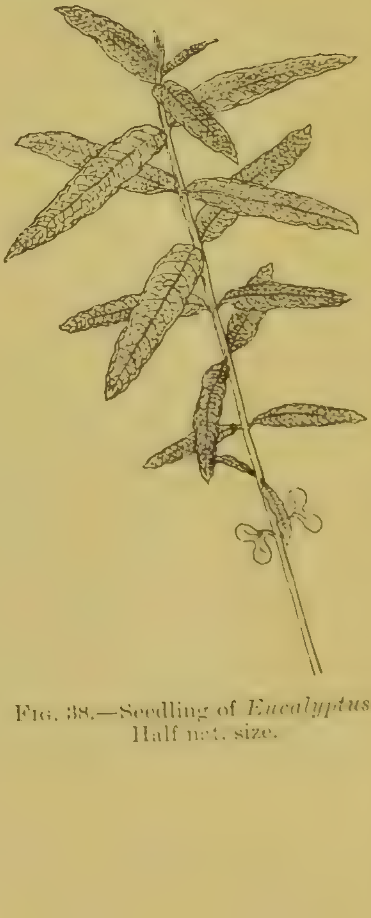

Fig. 38.—Seedling of *Eucalyptus* sp. Half nat. size.

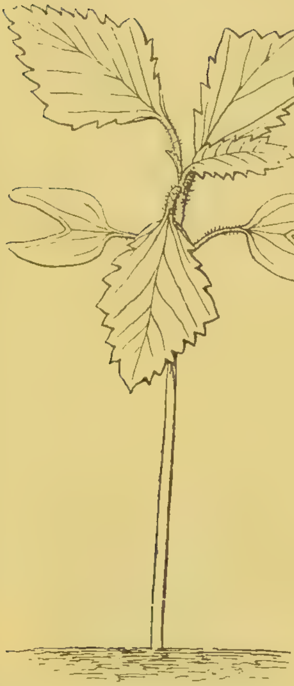

FIG. 39.—Seedling of *Pentapetes phœnicea.* Nat. size.

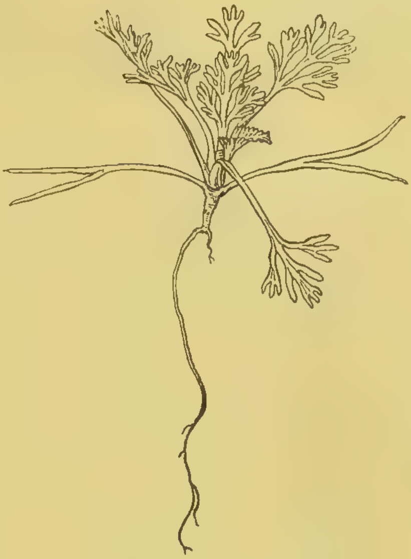

FIG. 40.—Seedling of *Eschscholtzia californica.* Nat. size.

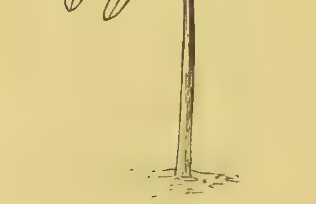

FIG. 41.—Seedling of *Pterocarya caucasica.* Nat. size.

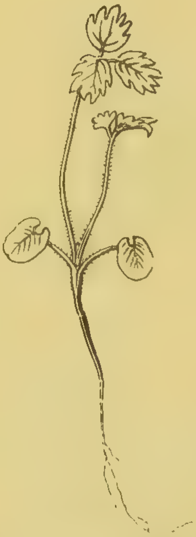

FIG. 42.—Seedling of *Poterium Sanguisorba.* Twice nat. size.

they are supported on petioles, as in Microloma (fig. 29), which again are occasionally connate. These differences may occur in very closely allied species; for instance, in Delphinium Staphysagria (fig. 31) the cotyledons are sessile, while in D. elatum (fig. 30) they are petioled, and in D. nudicaule (fig. 32) the petioles are connate.

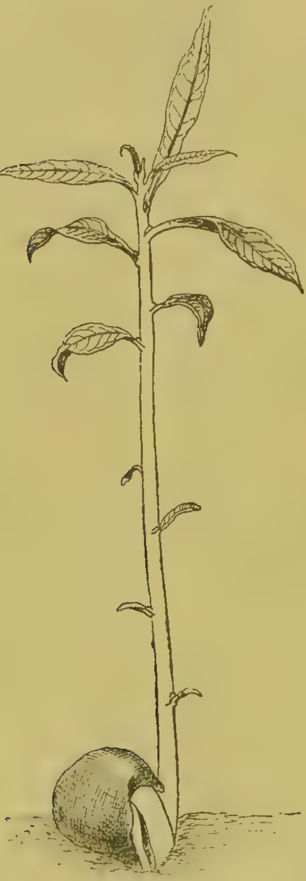

Fig. 43.—Seedling of *Sapindus inæqualis.* Half nat. size.

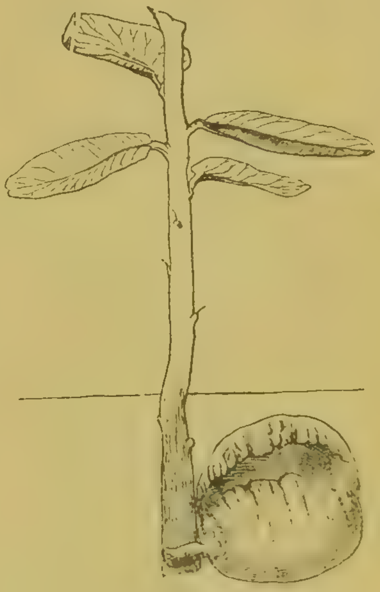

Fig. 44.—Seedling of *Rhus Thunbergii.* Half nat. size.

Generally the cotyledons are entire; but sometimes crenate, as in Cordia (fig. 33), or lobed, as in Pelargonium (fig. 34) and Malva (fig. 35). Often they are emarginate, as in Impatiens (fig. 12), Mustard (fig. 3), and Cabbage, Ipomœa (fig. 88), Convolvulus, Galium (fig. 92), Eucalyptus (fig. 38), Pentapetes (fig. 39), &c. They are sometimes even bifid, as in Eschscholtzia (fig. 40) and Ipomœa dasysperma (fig. 89); trifid, as in the Cress (*Lepidium*) (fig. 4); or in four long lobes, as in Pterocarya (fig. 41). Sometimes auricled at the base, as in Poterium (fig. 42) and Cuphea. Sometimes they are large; sometimes small. Generally they are leaf-like; but sometimes, as in Rhus Thunbergii (fig. 44), Sapindus (fig. 43), and among English plants in the Oak, Nut, Pea, Bean, Mercurialis perennis,[1] Melittis Melissophyllum,[2] Nymphæa, Nuphar, Rhamnus Frangula, Trientalis, Daphne, &c., they are thick and fleshy.

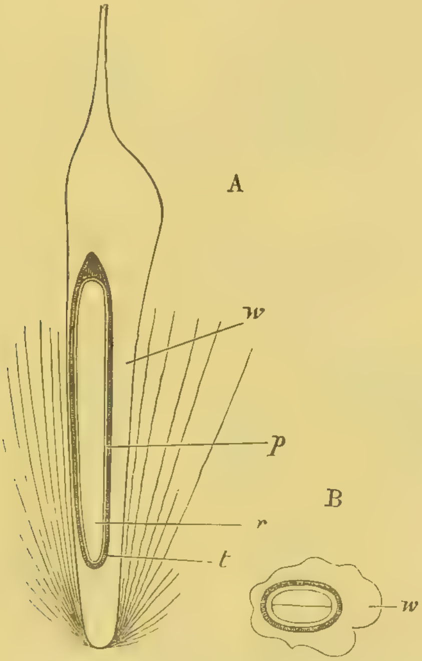

Fig. 45.—A, Fruit of *Platanus*, longitudinal section, × 6: *w*, woody part. B, transverse section, × 12.

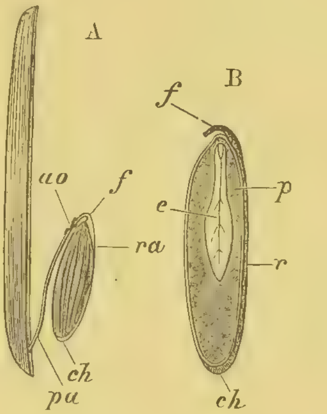

Fig. 46.—A, samara of *Fraxinus excelsior*, nat. size, with one half removed and the seed pulled out: *pa*, placental axis; *ao*, abortive ovule; *f*, funicle. B, longitudinal section of seed. In germination the embryo grows to the whole length of the seed.

Except where otherwise stated, *c* stands for cotyledon; *oc*, outer cotyledon; *ic*, inner cotyledon; *ch*, chalaza; *e*, embryo; *f*, funiculus; *h*, hilum; *m*, micropyle; *p*, endosperm; *r*, radicle; *t*, testa.

Narrow Cotyledons.

Let us now begin with such species as have narrow cotyledons, and see if we can throw any light on this characteristic. The problem is simple enough in such cases as Platanus, where we have on the one hand narrow cotyledons (fig. 8) and on the other hand a long narrow seed (fig. 45, *p*) fully occupied by a straight embryo. Again, in the Ash (*Fraxinus*) (fig. 46), Ursinia (fig. 47), &c., the cotyledons lie parallel to the longer axis of the seed, which is narrow and elongated. Such cases, however, are comparatively few; and there are a large number of species in which the seeds are broad and even orbicular, while yet the cotyledons are narrow, as for instance in Chenopodium (fig. 48) and Menispermum (fig. 49).

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[1] Winkler, 'Ueber die Keimpflanze des Mercurialis perennis,' *Flora*, 1880.

[2] Irmisch, 'Zur Naturg. v. Melittis,' *Bot. Zeit.* 1858, p. 233.

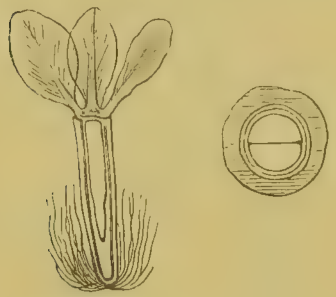

Fig. 47.—Achene of *Ursinia speciosa*. Longitudinal section, × 2½. Transverse section, × 10.

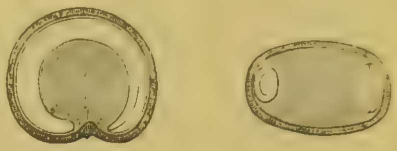

Fig. 48.—*Chenopodium Bonus-Henricus*, vertical and transverse sections of seed.

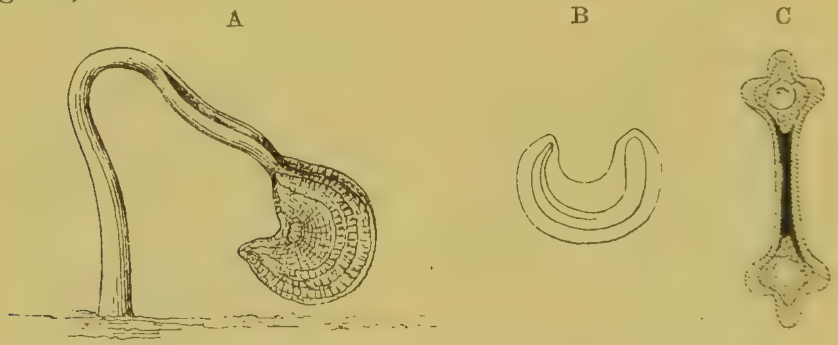

Fig. 49.—*Menispermum canadense.*

A, germinating, seedling, × 2. B, vertical section of seed, × 4. C, transverse section of seed, × 2.

In these it will generally be found that the cotyledons lie transversely to the seed. In Menispermum (fig. 18) the fruit (fig. 49) is laterally compressed and horseshoe-shaped, with a crest along the edge; the seed (fig. 49, B) conforms to the shape of the fruit, and the embryo is curved and linear, the cotyledons being applied to one another face to face, and at right angles to the plane of the seed, so that the edges of the cotyledons touch the walls of the seed at each side.

The Sycamore (*Acer Pseudo-Platanus*) (fig. 9) has also narrow cotyledons; but the arrangement is very different. The fruit (fig. 50) is winged, the seed somewhat obovoid and exalbuminous—that is to say, the embryo, instead of lying embedded in food-material, occupies the whole cavity of the seed. Now if we wished to pack a leaf into a cavity of this form, it would be found convenient to choose one of a long strap-like shape, and then roll it up into a sort of ball. This is, I believe, the reason why this form of cotyledon is most suitable in the case of the Sycamore. The mode of folding, however, as shown in fig. 50, A and B, is not always the same. I shall suggest a reason for the difference further on.

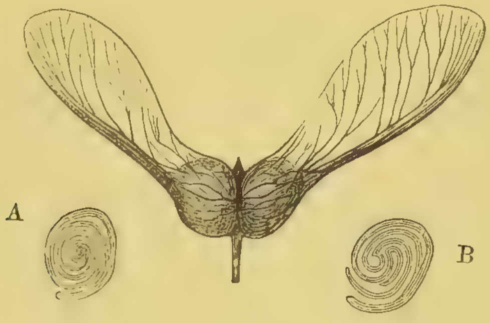

FIG. 50.—*Acer Pseudo-Platanus.* Fruit, nat. size. A, B, embryo, showing two modes of arrangement of cotyledons.

In other species the narrowness of the cotyledons is perhaps an advantage in facilitating the exit from the seed. See, for instance, the cases of Galium (p. 28) and Symplocos.

BROAD COTYLEDONS.

I now pass to species with broad cotyledons. The Acorn Nut, Bean (*Phaseolus*) (fig. 51), and Pea afford familiar cases, in which the two broad, fleshy, thickened cotyledons conform to and occupy the whole seed. In the Castor-oil plant (*Ricinus*) (fig. 11) the seed (fig. 52) is ovoid-oblong, somewhat compressed dorso-ventrally, and beautifully mottled, while the projecting knob at the hilum gives it very much the appearance of a beetle or large tick. The endosperm is abundant, fleshy, white, and surrounds the embryo. The embryo is straight, flat, large, central, and white; the cotyledons broad, obtuse-oblong, and approximately following the general outline of the seed. In Hippophaë (fig. 14) we have a somewhat similar case; but the cotyledons are fleshy and occupy almost the whole of the seed (fig. 53). In Euonymus, again, the seed is obovoid, slightly compressed laterally. The endosperm is abundant, fleshy, firm, and white, entirely surrounding the embryo. The embryo is straight, flat, central, pale green, extending very nearly from one end of the seed to the other. In the Flax the seed is ovate, obliquely pointed, glabrous, plano-convex, laterally much compressed, placed edgeways on the placenta, and the cotyledons lie parallel to the flattened axis of the seed. In other cases the seeds are still more flattened, as in Ailanthus, Passiflora, Cobæa, Stephanotis, &c.

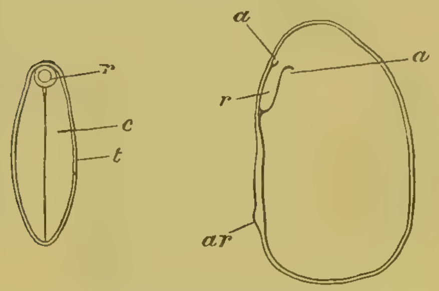

Fig. 51.—*Phaseolus multiflorus.* Section of seed parallel and vertical to cotyledons, three-fourths nat. size: *a*, *a*, auricles; *ar*, arillode.

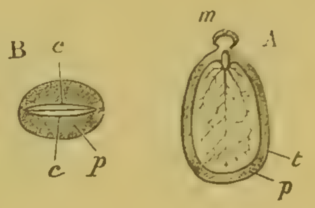

Fig. 52.—*Ricinus sanguineus.* A, longitudinal section of seed, nat. size. B, transverse section of seed, nat. size.

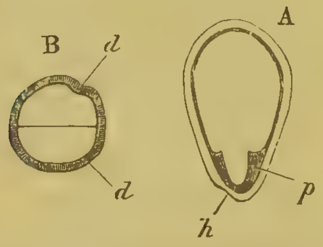

Fig. 53—*Hippophaë rhamnoides.* A, longitudinal section of seed, × 4. B, transverse section of seed, × 4: *d d*, depressed line.

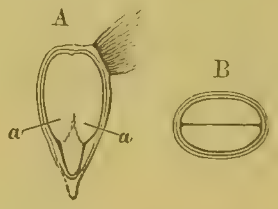

Fig. 54.—*Moscharia pinnatifida.* A, longitudinal section of seed, × 8. B, transverse section of seed, × 8: *a a*, auricles.

The Compositæ generally have narrow cotyledons. In Moscharia, however, they are somewhat broader, the seed (fig. 54) being obovoid, with the cotyledons lying the broad way.

In many cases, seeds of the same shape produce cotyledons of very different form.

Compare together, for instance, Ruellia (fig. 55) and Cerastium (fig. 23 seedling, and fig. 56 seed). Both have compressed, nearly orbicular seeds, but in Ruellia the cotyledons are broad, in the Chickweed they are narrow. If, however, we make sections of the seeds, the cause of this difference becomes obvious, because in one (fig. 55) the cotyledons lie parallel, in the other (fig. 56) transverse, to the seed.

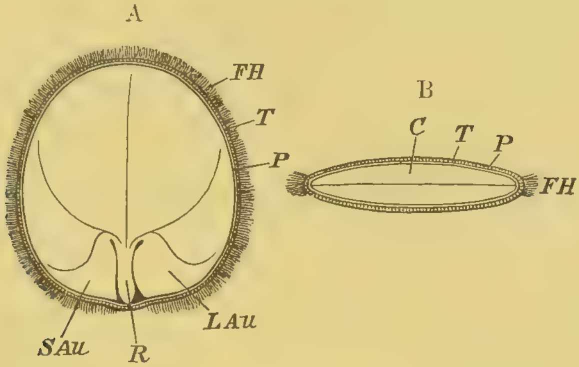

Fig. 55.—*Ruellia longifolia*. A, longitudinal section of seed, × 10. B, transverse section of seed, × 10: FH, fringe of hairs; LAu, larger, and SAu, smaller auricle.

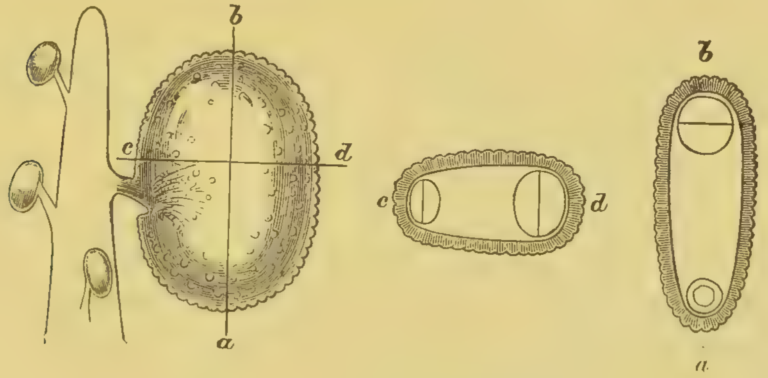

Fig. 56.—*Cerastium arvense*, × 15.

The form of the cotyledons often differs greatly even in the same family.

The Caryophyllaceæ, for instance, afford us an interesting illustration. The cotyledons in this family are placed with their backs to the placenta, and in most species are narrow, as in Cerastium (figs. 23 and 56). In some of them, however, such as the Pink itself (*Dianthus*) (fig. 22) and Tunica, they are wide.

Now in most genera, as in Stellaria, Spergularia, Cerastium, &c., the seeds are laterally compressed; the cotyledons consequently lie transversely to the seed, and their width therefore is limited by the thickness of the seed, as in fig. 56. The case is, however, somewhat complicated by the fact that the seed and embryo are both curved.

On the other hand, in the Pink (fig. 57) the seeds are not laterally but dorsally compressed, attached to the columnar placenta by the middle of the interior face, so that the cotyledons are straight, parallel to the seeds, and have in consequence plenty of room to widen out.

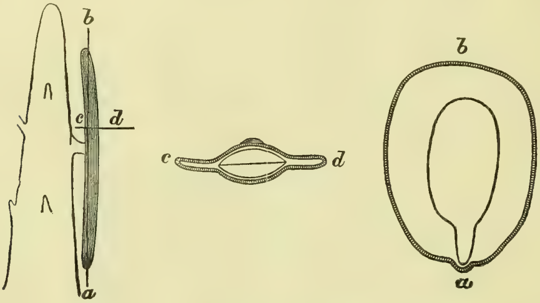

Fig. 57.—*Dianthus Caryophyllus*, × 15.

(In figs. 56 and 57 the letters *a*, *b*, and *c*, *d* indicate the directions of the sections.)

In Solanum the fruit is roundish, glabrous, indehiscent, and many-seeded. The seeds are kidney-shaped, much compressed laterally, and placed with their narrow edge to the placenta, surrounded by a paler margin, glabrous and white; the hilum is small, and on the middle of the ventral edge. The embryo is, in the mature seed, much curved, embedded in, but lying near the outer edge of, the endosperm. The radicle occupies the lower and narrow part of the seed. The cotyledons are linear, not broader than the radicle, curved, with their tips close to the hilum, and their back to the placental axis, and at right angles to the plane of the seed, the whole width of which accordingly they occupy, so that they cannot grow any wider. On the other hand, while the fruit of Cestrum is not very unlike that of Solanum, the seeds are very different in shape, being peltate, more or less obovate, with the broad end towards the apex of the seed, so that the cotyledons have room to widen themselves.

Sometimes we meet with species having both narrow and broad cotyledons, even in the same genus. For instance, Coreopsis filifolia (fig. 6) has narrow, Coreopsis auriculata broad, cotyledons. If, however, we examine the seeds we find that those of C. filifolia are narrow or subcylindrical (fig. 58), while those of C. auriculata (fig. 59) are broadly obovate; and as in both cases the embryo fills the seed, this difference sufficiently accounts for the dissimilarity in the cotyledons.

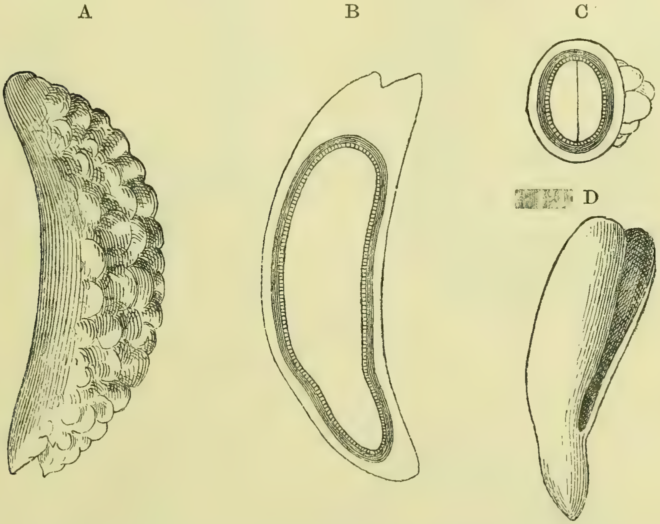

Fig. 58.—*Coreopsis filifolia.* A, achene, × 14. B, longitudinal section, × 14. C, transverse section, × 14. D, embryo, × 14.

The genus Galium is an interesting case. Here also we find some species with narrow, some with broad, cotyledons; but the contrast seems to be due to a very different cause. G. Aparine (fig. 91) has broad, G. saccharatum (fig. 24) narrow, cotyledons. In G. saccharatum the fruit (fig. 60) deeply lobed, two-celled, two-seeded, indehiscent, and densely covered with tubercles. The seed is globose, deeply hollowed on the ventral surface. The embryo (fig. 60, *r*, *c*) is curved, following the concavity of the hollow, with the larger part of the endosperm lying towards the periphery. The cotyledons are linear and obtuse. Fig. 60 shows that, so far as the form of the seed is concerned, there is no reason why the cotyledons should not be much broader than they are. The explanation may perhaps be found in the structure of the pericarp (fig. 60, *p.c*), which is thick, tough, and corky. It is very impervious to water, and may be advantageous to the embryo by resisting the attacks of drought and of insects, and perhaps if the seed be swallowed by a bird, by protecting it from being digested. On the other hand it does not split open, and is too tough to be torn by the embryo. The cotyledons, therefore, if they

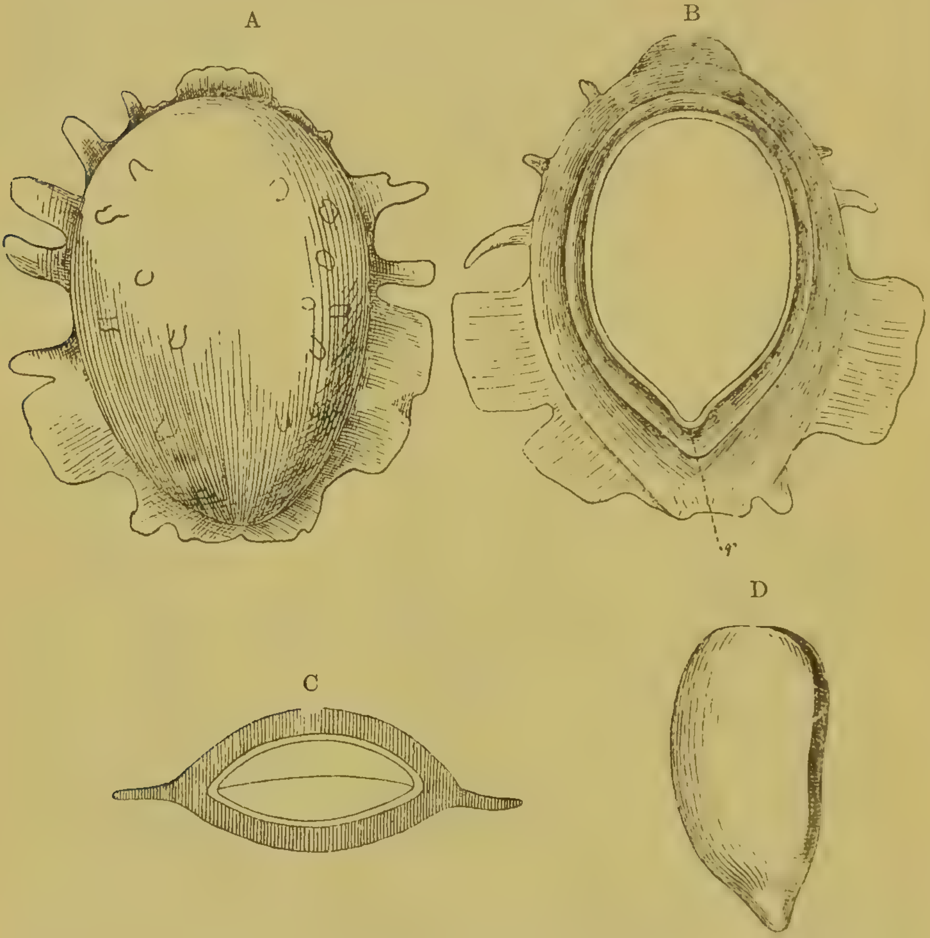

Fig. 59.—*Coreopsis auriculata*. A, achene, × 14. B, longitudinal section, × 14
C, transverse section, × 14. D, embryo, × 14

had widened, as they might otherwise have done, would have found it impossible to emerge from the seed. They evade the difficulty, however, by remaining narrow (fig. 60, C). On the other hand, in G. Aparine the pericarp is much thinner (fig. 61), and the embryo is able to tear it open (fig. 61, C). In this case, therefore, the cotyledons can safely widen without endangering their exit from the seed.

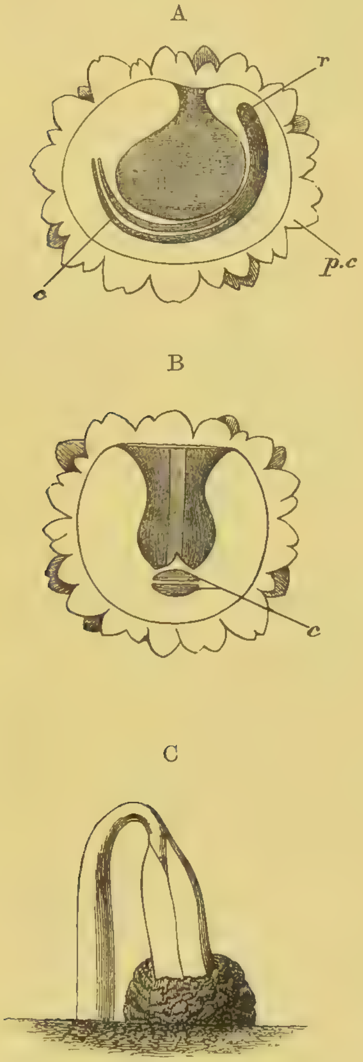

Fig. 60.—*Galium saccharatum.* A, longitudinal section of seed, × 8. B, transverse section of seed, × 8. C, germinating seedling, × 4.

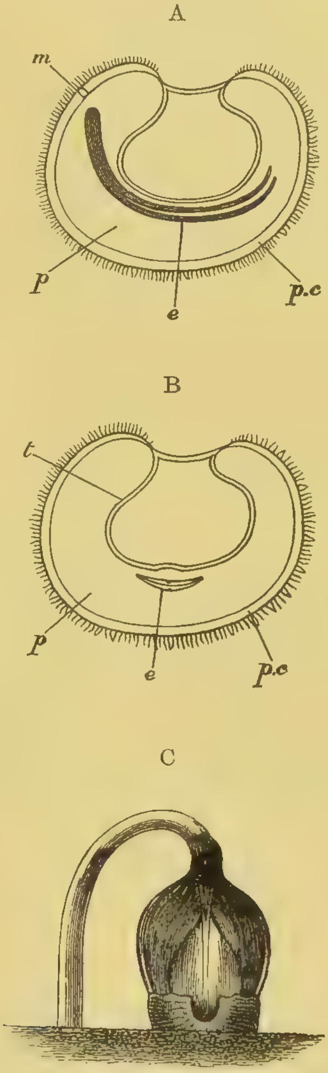

Fig. 61.—*Galium Aparine.* A, longitudinal section of seed, × 8. B, transverse section of seed, × 8. C, germinating seedling, × 4.

The thick corky covering of G. saccharatum is doubtless much more impervious to water than the comparatively thin testa of G. Aparine. The latter species is a native of our own isles, while G. saccharatum inhabits Algiers, the hotter parts of France, &c. May not, then, perhaps the thick corky envelope be adapted to enable it to withstand the heat and drought?

In all these species the cotyledons are flat or nearly so, but a large number are enabled to widen themselves by being more or less folded. One form of this is afforded by the Radish (*Raphanus*) and Brassica (fig. 3). Fig. 62, A, shows a seed of Raphanus sativus, and, as shown in fig. 62, B–E, the latter of which represents a young seedling, the cotyledons are applied to one another face to face, and then folded along the middle.

UNEQUAL COTYLEDONS.

I now turn to those species in which the two cotyledons are unequal in size.

Several of these cases have been discussed by Darwin,[1] who attributed the inequality to the fact of 'a store of nutriment being laid up in some other part, as in the hypocotyl, or one of the two cotyledons, or one of the secondary radicles.' I differ with the greatest hesitation from so high an authority; but do not see the connection between the store of food being partly laid up in some other part of the plant and the inequality between the cotyledons. Why should it affect one more than the other? I venture to suggest that the difference is due rather to the position of the embryo in the seed, which in some cases favours one cotyledon more than the other. For instance, in many cases the cotyledons are what is called 'incumbent,' that is to say the radicle is folded upon one of the cotyledons, and in such species the outer cotyledon is often rather larger than the other, as for instance in Hesperis matronalis.

The Hemp (*Cannabis*) and Caylusea present us with cases more or less resembling that of Hesperis.

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[1] *Movements of Plants*, p. 94.

In the Mustard (fig. 3), Cabbage, Radish (*Raphanus*), and some other Crucifers, the difference is more marked, and is due to a different cause. The cotyledons, as just mentioned, are applied to one another face to face (fig. 62, B–D), and then doubled longitudinally one inside the other. The outer one, therefore, having more space, becomes larger and the petiole is longer. In Cereus (fig. 63) the embryo is much

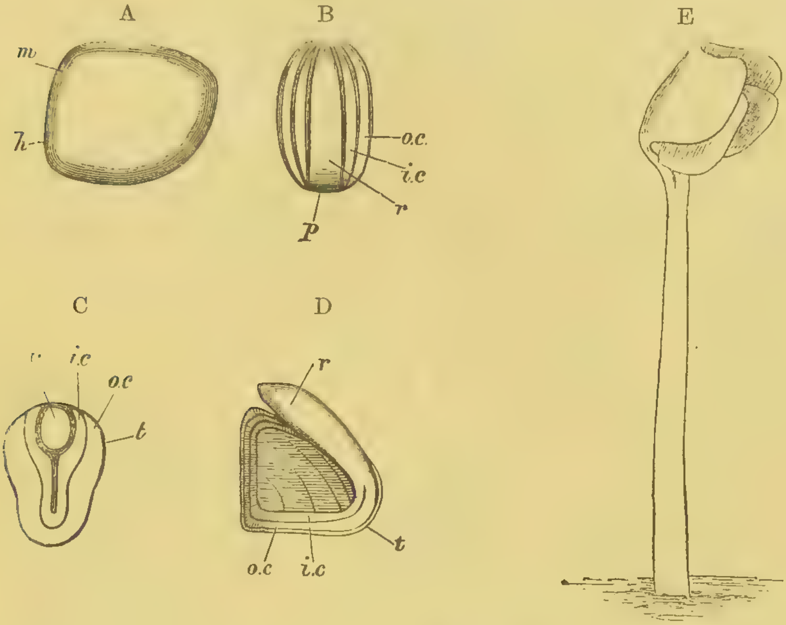

FIG. 62.—*Raphanus sativus.* A, outline of seed, × 4 : *m*, micropyle; *h*, hilum. B, embryo extracted from seed, × 4. C, embryo, × 4; vertical section. D, embryo, seen from the side, × 4 : *o.c*, outer cotyledon; *i.c*, inner cotyledon; *r*, radicle; *t*, testa. E, germinating seedling, × 2, showing the cotyledons still folded.

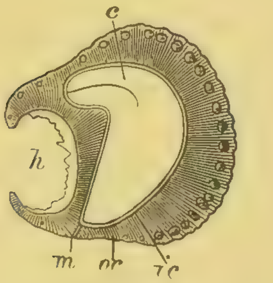

FIG. 63—*Cereus Napoleonis.* Section of seed: *oc*, outer coat of testa; *ic* inner coat of testa

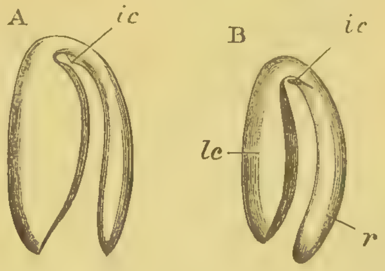

FIG. 64.—A, embryo of *Abronia arenaria*, × 6 : *ic*, smaller cotyledon. B, embryo of *A. umbellata*, × 6 : *ic*, right and inner cotyledon; *lc*, left cotyledon

curved, and the cotyledons being thick and fleshy, the inner one is naturally smaller than the outer.

In Abronia umbellata (fig. 64, B) the embryo is large, much curved or doubled on itself, and lies outside the endosperm, the two edges of the cotyledon reaching almost to the radicle. The second cotyledon (*ic*) is minute, generally not more than one-seventh the length of the outer one, though in one seed it attained nearly half the length of the other. In another species of the same genus, A. arenaria, the smaller cotyledon is reduced to a mere knob (fig. 64, A, *ic*).

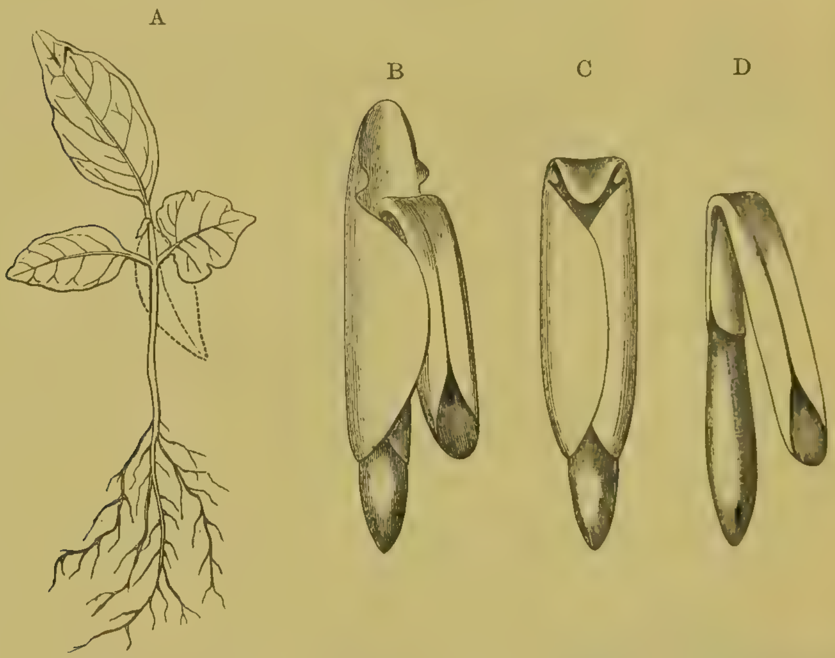

FIG. 65.—*Petiveria octandra.* A, seedling, half nat. size. B, embryo partly unfolded × 6. C, outer and shorter cotyledon. D, inner and longer cotyledon.

Cases in which one of the cotyledons is rudimentary also occur in the genera Ranunculus,[1] Carum,[2] Cyclamen, &c.

In Petiveria octandra (fig. 65, A) the cotyledons are very interesting. The one is about 3 cm. long, $1\frac{1}{4}$ broad, oblong, tapering at both ends, and entire. The other is shorter and broader, 2 cm. long by $1\frac{3}{4}$ broad, subcordate, with a large terminal lobe, and one, more or less pronounced, on each side. At first I thought this curious want of symmetry must be accidental. It is, however, normal, and is explained by the peculiar form and arrangement of the embryo (fig. 65, B–D) in the seed. The fruit is an achene of peculiar form; it is oblong-linear, subcuneate, and laterally compressed, bifid at the apex, and crowned with 2–6 unequal, closely reflexed, acute bristles, more or less hairy, one-celled, one-seeded, and indehiscent. The seed is oblong-linear, and tapers somewhat, conforming to the interior of the fruit. The embryo is large; the inner cotyledon is doubled on itself; the outer one is also turned over at the end, and wraps round the narrower one,[1] not reaching, however, to the narrow end of the seed: the terminal lobe of the shorter and broader cotyledon is the part which is folded over, and the lateral lobes, which are much smaller in the embryo, are also due to the fold, as shown in fig. 65, B–D.

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[1] See Irmisch, *Beit. zur vergl. Morphol. der Pflanzen* (Halle, 1854).

[2] Hegelmaier, *Vergl. Untersuchungen* (Stuttgart, 1878).

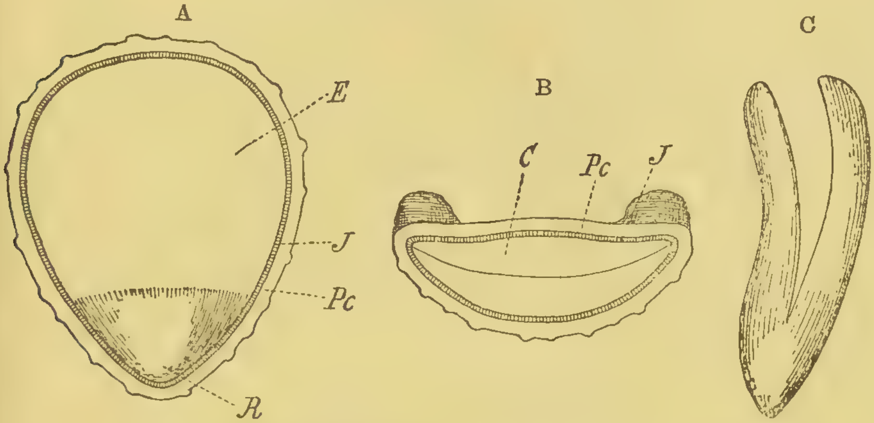

FIG. 66.—*Coreopsis Atkinsoniana.* A, longitudinal section of achene, × 10. B, transverse section of achene, × 10. C, embryo, × 10.

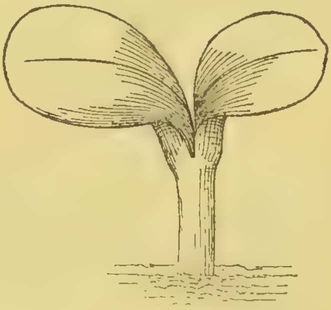

FIG. 67.—*Coreopsis Atkinsoniana.* Seedling, × 10.

In Coreopsis Atkinsoniana the seeds are obovate, curved longitudinally, and compressed dorso-ventrally, conforming to the interior of the fruit. The embryo again is slightly bent, following the direction of the seed. Consequently the one cotyledon occupies the inner, the other the outer side of the curve; and, as shown in fig. 67, the outer one is distinctly larger than the other.

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[1] The narrow cotyledon is sometimes absent.

In Thunbergia reticulata the cotyledons are unequal, ovate, obtuse, slightly emarginate, and cordate at the base. The larger one is slightly denticulated, and has a curious embossed area in the centre; the smaller one is, on the contrary, smooth and entire, or nearly so. The seed is orbicular or oblong; exalbuminous, 3–4 mm. in diameter, compressed, with a cavity on the inner side. The embryo is slightly curved; and the cotyledons lie with their faces towards the hilum, which is very prominent; the inner cotyledon is turned up at the edges, and wraps, to a certain extent, round the outer one. The raised or embossed patch in the centre of this cotyledon is due to the inward curvature of the testa.

UNSYMMETRICAL COTYLEDONS.

In other cases, as in the Geraniums (fig. 25), Schinus (the False Pepper) (fig. 28), Clitoria (fig. 27), Laburnum (fig. 26), Lupines, &c., there is inequality, not between the two cotyledons, but between the two halves of each cotyledon. In the Geraniums this is due to the manner in which the cotyledons are folded. In the Cabbage and Mustard we have seen that one cotyledon is folded inside the other; in the Geranium they are convolute (fig. 68), one half of each being folded inside one half of the other—the two inner halves being the smaller, the two outer the larger ones.

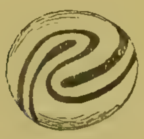


FIG. 68.—Section through embryo of *Geranium*, showing the mode of folding of the cotyledons.

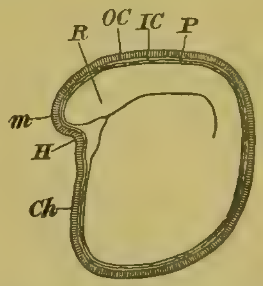


FIG. 69.—Seed of *Laburnum vulgare*, × 6: *OC*, outer coat; *IC*, inner coat.

In the Laburnum (fig. 26) and in Clitoria (fig. 27), on the other hand, the inequality in the two sides of the cotyledon is due to the inequality between the two sides of the seed (fig. 69).

In Heritiera macrophylla the cotyledons fill the seed, which conforms to the shape of the carpels, and the fact that these are somewhat unequal-sided renders the seed and consequently the cotyledons so likewise.

In the Lupines the seeds are obliquely oblong, compressed laterally, and without endosperm, the embryo being large, fleshy, yellowish, and occupying the whole seed. It is doubled on itself, and the cotyledons are folded along the radicle, which nearly equals them in length, with the smaller halves turned towards the radicle, and in such a manner that they and the radicle together occupy one half of the seed, and about equal the larger halves of the cotyledons, which fill the other.

In Triphasia the inequality is due, partly at any rate, to a different cause. The seeds are oval, somewhat flattened, especially on the ventral aspect. The embryo is large, and occupies the whole seed. The cotyledons are very unequal in size, and the smaller one is more or less enclosed in the larger. But, in addition to this, there are often, indeed generally, two and sometimes three embryos in each seed; these differ in size, and the smaller ones often intrude more or less on one of the cotyledons belonging to the larger ones.

CRENATE COTYLEDONS.

The vast majority of plants have the edges of the cotyledons entire. There are some few, however, in which they are more or less crenate, as for instance in Cordia subcordata (fig. 33).

In this species the embryo occupies the whole of the ovoid-conical seed. There is no endosperm, and the cotyledons, in order to occupy the whole space, are longitudinally folded (fig. 70), thus giving rise to the crenations on the margin.

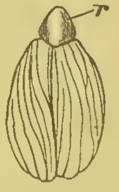


FIG. 70.—Embryo of *Cordia subcordata*, × 2.

ACCUMBENT AND INCUMBENT COTYLEDONS.

There are two ways in which the radicle may be bent over the cotyledons.

Sometimes it is turned up over the back of one of the cotyledons, as in figs. 71 and 72, and is said to be incumbent;

FIG. 71.

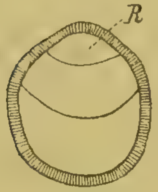
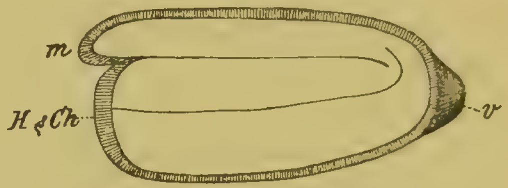


FIG. 72.



FIGS. 71 and 72.—Sections of seed of *Hesperis matronalis*, × 10: *v*, hollow in testa.

while sometimes it is turned along the edge of the cotyledons, as in figs. 73 and 74, which are then termed accumbent. The divisions of the Cruciferæ are based to some extent on this character, some groups being accumbent and some incumbent. I puzzled for some time over the reasons which could account for this difference, though the explanation

FIG. 73.

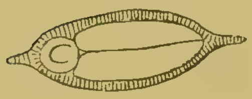
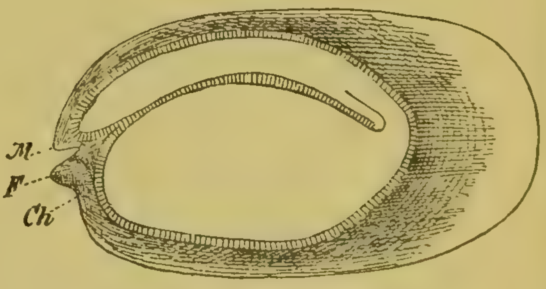


FIG. 74.



FIGS. 73 and 74.—Section of seed of *Cheiranthus Cheiri*, × 10.

which I would suggest is very simple when once stated. I scarcely feel justified however in doing more than throwing it out as a suggestion.

Seen in section the two forms would be as shown in figs. 71 and 73. Now if from the form of the pods, or for any other reason, it is an advantage that the seed should be compressed, as in fig. 73, then, the thickness of the cotyledons remaining the same, it is better that the radicle should be accumbent; while, on the other hand, in a thicker or globular seed, as in fig. 71, the incumbent arrangement is most convenient. In fact we find that in groups, such as the Arabideæ, where the seeds are as a rule compressed, the radicle is almost always accumbent; while in incumbent groups, such as the Sisymbrieæ, they are, on the contrary, more or less turgid.

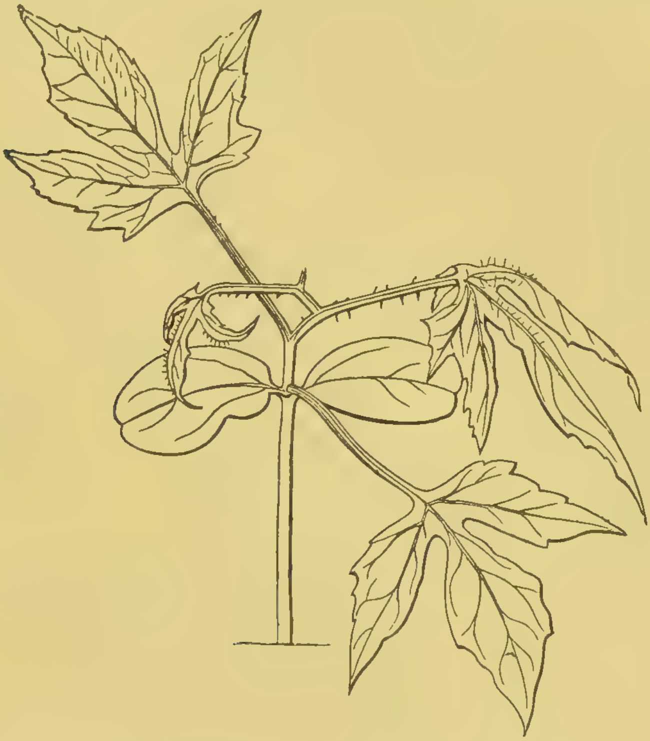


Fig. 75.—Seedling of *Bryonia laciniosa*. Half nat. size.

As an actual example of an incumbent form I give Hesperis matronalis (figs. 71 and 72), and of an accumbent, Cheiranthus Cheiri (figs. 73 and 74).

Petioles.

The cotyledons are sometimes sessile, as in Acer (fig. 9), Hippophaë (fig. 14), Hakea (fig. 21), Clitoria (fig. 27); sometimes supported on petioles, which in many cases, as in Microloma (fig. 29), attain a considerable length.

Occasionally we meet with both sessile and petioled cotyledons even within the limits of the same genus. For instance, Delphinium Staphysagria (fig. 31) has the cotyledons sessile, while those of D. elatum (fig. 30) have petioles. In Bryonia laciniosa (fig. 75) the cotyledons are nearly sessile, while those of B. dioica (fig. 76) have petioles.

There is nothing, so far as I know, in the structure of the seed to account for this difference. It is observable, however, that while the cotyledons of Bryonia laciniosa (fig. 75) and those of D. Staphysagria (fig. 31) are raised by the hypocotyl somewhat above the level of the ground, those of Bryonia dioica (fig. 76) and of D. elatum (fig. 30) are attached close to the ground. In fact the cotyledons are carried up in both cases, but in B. laciniosa and D. Staphysagria by the hypocotyledonary portion of the axis or stalk of the plant, in B. dioica and in D. elatum, on the other hand, by their own petioles.

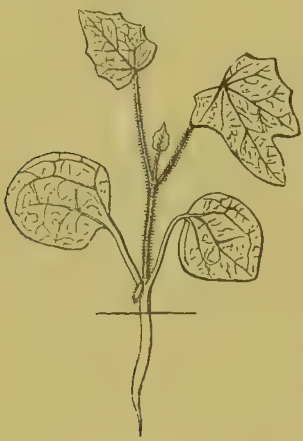


FIG. 76.—Seedling of *Bryonia dioica*. Nat. size.

I may also refer to Vitis hypoglauca and V. cebennensis, the former with a short hypocotyl and long petioles, the latter with a long hypocotyl and short petioles.

In short, we may say that the cotyledons are, as a general rule, sessile when they are raised by the growth of the hypocotyl, while they are petiolate when they take their origin close to the ground. There are, no doubt, some exceptions; for instance, in some species of Hedysarum the cotyledons are radical and yet sessile. I have, however, often in Algeria seen seedlings of this group in hot exposed situations, where they 'held the field' alone, and being sure of ample heat and light did not require to be raised above the surface.

The opposite exception is perhaps more common—*i.e.* when the cotyledons, though raised, are still petiolate. Here, however, the cotyledons are probably petiolate for the same reason as the leaves—viz., when the foliage is large, leaf-stalks are an advantage in carrying the lower leaves out of the shadow of those immediately above them.

In another species of Delphinium (*D. nudicaule*) (fig. 32) the cotyledons are raised well above the surface of the ground on a stem consisting of their own two stalks or petioles, which are connate, though readily separable from one another. Connate cotyledons also occur in Phlomis tuberosa, Smyrnium perfoliatum (fig. 77), Polygonum Bistorta,[1] &c. Gray[2] observes that the economy of this arrangement is not apparent. Assuming, however, that the elevation of the cotyledons is an advantage, perhaps, as I have suggested, from carrying them above the surrounding herbage, the combination of the two petioles—reversing the old fable of the bundle of sticks—would, with the same amount of material, give a considerable addition of strength.

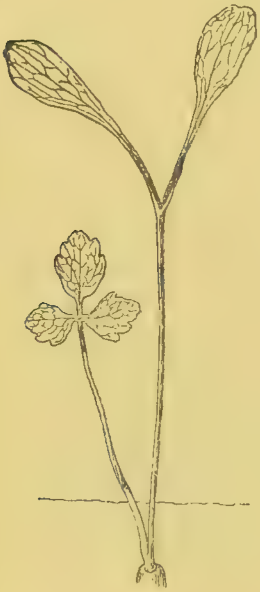


FIG. 77.—Seedling of *Smyrnium perfoliatum*. Half nat. size

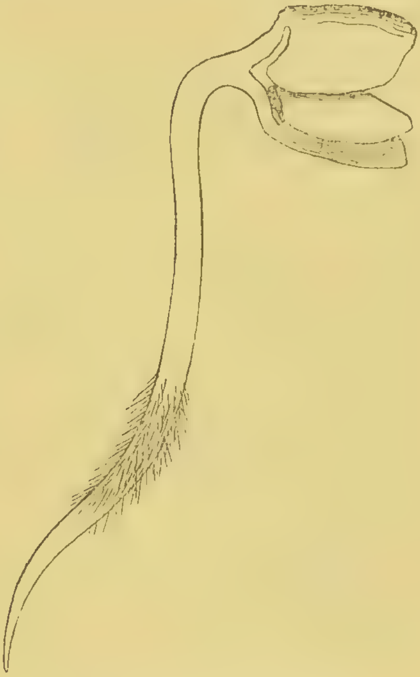


FIG. 78.—Germinating seedling of *Geranium bohemicum*, × 6.

For instance, in Smyrnium perfoliatum (fig. 77) the hypocotyl is undeveloped, the cotyledons are oblong-elliptic, emarginate, obtuse, generally unequal-sided or subfalcate, with long petioles, 3-nerved from the base, and finely reticulate, connate into one terete piece for 55–75 mm. of their length, split a little way at the base to allow the plumule to emerge, free in the upper part, semiterete and slightly channelled above.

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[1] Winkler, 'Ueber die Keimblätter der deutschen Dicotylen,' *Bot. Verh. Brandenburg*, 1874.

[2] *Structural Botany*, p. 21.

In this case it is obvious that if the petioles had been separate, they would have been far too weak to stand upright, and their length therefore would have been comparatively useless.

In Polygonum polystachyum, again, the petioles are connate and form a hollow tube through which the leaves pass ; so that the seedling has the appearance of possessing an erect hypocotyl with nearly sessile cotyledons.

In other cases, however, the existence of petioles apparently has reference to the arrangement of the embryo in the seed.

In the Geraniums, for instance, as has been already mentioned, the cotyledons are folded on themselves, one half of each lying within the other. Fig. 78 represents an embryo partially unfolded, and it will be seen that in the position assumed by the cotyledons the petioles are necessarily as long as half their breadth. In Eucalyptus Globulus, again (fig. 90), the mode of folding of the cotyledons would be impossible but for the petioles.

Lastly, in cases where the cotyledons do not leave the seed, the petioles leave room for the free growth of the plumule, as in Sapindus (fig. 43).

LOBED COTYLEDONS.

The great majority of cotyledons are entire, but some are more or less lobed. For instance, those of the Mallow (fig. 35) are broadly ovate, minutely emarginate, cordate at the base, and three-lobed or -angled towards the apex, with three veins, each running into one of the lobes.

Those of Lavatera and Althæa are similar. The embryo is green, curved, and occupies a great part of the seed. The cotyledons are applied face to face ; then, as growth continues, the tip becomes curved, and depressed into a median longitudinal furrow, the fold of the one lying in that of the other.

The embryo is of the form shown in fig. 79: the horn or process *r* is the radicle; the rest is the cotyledon, of which the free end *f* is folded on itself and turned downwards. In this way the embryo fills the seed, leaving a small space between the cotyledons and also between *f* and *r* which is occupied by endosperm. Perhaps it may make the arrangement clearer to take a piece of note-paper, cut it into the form of an egg (fig. 80), turn the broad portion *a b* downwards, so that the parts *a* and *b* have their under faces turned to one another, and then press down the line *e f*, and bring the points *c* and *d* together, so that *c e f* and *d e f* have their upper surfaces together, and the apex *f* pointing downwards. We shall then have an object shaped as in fig. 81, with a sharp point at *c*, which would not conform to the rounded shape of the seed. If, now, to make it do so, we cut off the point *c* along the dotted line and then unfold the paper, we shall find that it has the form of the cotyledon of Malva (fig. 35) with a bay or notch on each side. In Erodium the arrangement is somewhat similar, and it seems clear that the lobes are due to the manner in which the embryo is folded.

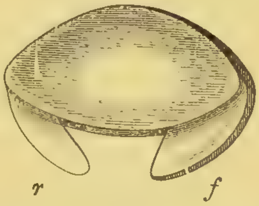

Fig. 79.—Embryo of Mallow. Enlarged.

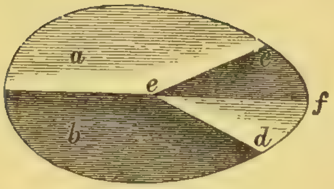

Fig. 80.

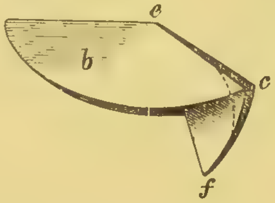

Fig. 81.

Figs. 80 and 81.—Piece of paper prepared to show the mode and effect of the folding of the embryo.

In Œnothera and some allied species the cotyledons also present a terminal lobe. This, however, is not due to folding.

The terminal lobe is the original cotyledon, and the basal portion is altogether subsequent growth, which, moreover, to some extent, assumes the character of the true leaf. I shall presently refer to this interesting group in more detail.

The case of Petiveria octandra (fig. 66) has been already described.

Emarginate Cotyledons.

In a great many species the cotyledons are emarginate, and even in some more or less deeply bifid. No explanation of this has, so far as I know, yet been offered. It is, in fact, as I shall hope to show, by no means always due to the same cause.

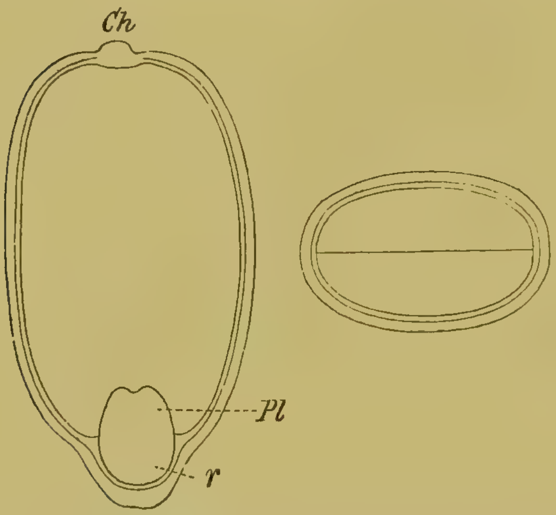

Fig. 82.—Longitudinal and transverse sections of seed of *Impatiens parviflora* × 10: *Pl*, plumule.

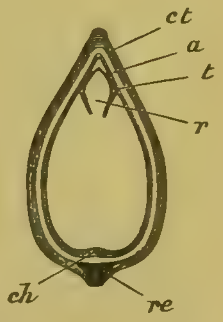

Fig. 83.—Longitudinal section of *Poterium Sanguisorba*, × 9: *ct*, calyx-tube; *a*, achene; *re*, receptacle.

One of the simplest cases is that of the Oak, where the thick fleshy embryo occupies the whole of the seed. The chalaza is situated at the centre of one end, at the extremity of the cotyledons, and the walls of the seed being at that point somewhat thickened, the cotyledons are slightly pressed in. The same explanation applies to various other species, as, for instance, to the Impatiens (figs. 12 and 82), Poterium (figs. 42 and 83), Cuphea (fig. 84), and Nettle (*Urtica*) (fig. 85).

In Helianthus Cucumis the seed itself is slightly notched at the point where it articulates with the receptacle; and the cotyledons, which, with the rest of the embryo, eventually occupy the whole interior of the seed, conform to this notch.

In such cases as the Mustard (fig. 3), Cabbage, and Radish, the emargination is due to a totally different cause. The seed (fig. 62, A) is oblong, thick, and slightly narrower at one end than the other. There is no endosperm, so that the embryo occupies the whole seed, and as this is somewhat deep, the cotyledons, in order to occupy the whole space, are folded and arranged one over the other, like two sheets of note-paper, as shown in fig. 62, B–E, the radicle being folded along the edge.

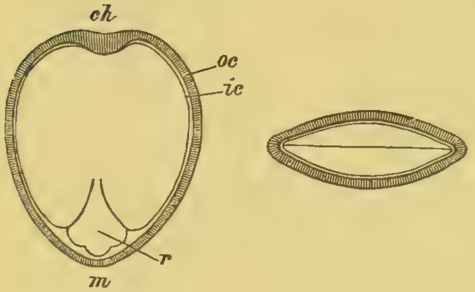

Fig. 84.—Longitudinal and transverse sections of seed of *Cuphea silenoides*, × 10 : *oc*, outer coat; *ic*, inner coat.

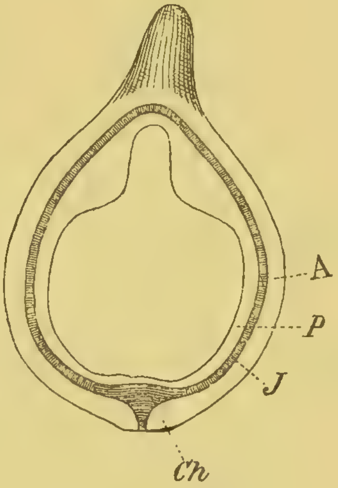

Fig. 85.—Achene of Nettle (*Urtica dioica*), × 30 : *J*, testa.

Fig. 62, D, represents the embryo a little opened out; and fig. 62, C, a section showing the radicle and the outer and inner cotyledons. To this folding the emargination is due. If a piece of paper be taken, folded on itself, cut into the form shown in fig. 62, A, with the fold along the edge from *m* to *h*, and then unfolded, the reason for the form of the cotyledon becomes clear at once. Zilla myagroides affords a similar case.

But it may be said that in the Wallflower the seed has a similar outline, and yet (fig. 86) the cotyledons are not emarginate. The reason of this is that in the Wallflower (*Cheiranthus*) (figs. 73, 74) the seed is more compressed than in the Mustard and Radish (fig. 62, B, C), and the cotyledons are not folded; so that the whole, not the half, of each cotyledon corresponds to the form of the seed.

In the Bignoniaceæ, again, a large number of species have emarginate cotyledons; and this would appear also, as for instance in Pithecoctenium Aubletii, to be due to the chalaza, though in a different manner. The seeds themselves are transversely oblong, much compressed dorsally, surrounded on all sides except the base by an extremely thin, transparent, membranous wing, which is traversed by nerves radiating from the central part of the testa, and is uneven at the margin. The raphe is ventral, extending from the hilum to the centre of the embryo. The chalaza is attached to the embryo-sac a little above the middle of the embryo. The radicle is very small, distant from, but pointing to, the hilum. The embryo is straight and flat; the cotyledons grow until they come to the point of attachment of the chalaza, when they extend forwards on each side, forming two lobes.

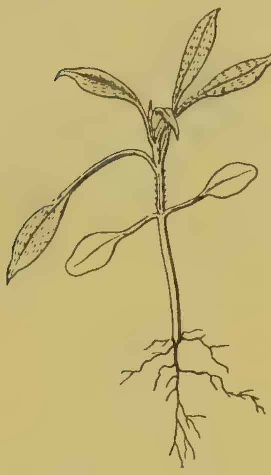

Fig. 86.—Seedling of *Cheiranthus Cheiri.* Two-thirds nat. size.

In Oroxylum indicum the general structure of the seed is very similar, but the growth of the two lobes of the cotyledons is even more luxuriant, so that they actually overlap. A structure more or less similar occurs in other genera of this family.

The emargination is very much deeper in other groups, and due to other conditions, for instance in the Convolvulaceæ. In Convolvulus Soldanella (fig. 87) the embryo, which is eventually very large, lies at first straight in the seed embedded in a clear jelly-like endosperm, and rests on a solid ovate, grooved, white ridge (fig. 87, B and C, *a*), which rises from close to the micropyle. This tongue-like ridge grows with the embryo. At the opposite end of the seed the raphe and chalaza form a somewhat prominent ridge (*b*) projecting into the endosperm. The cotyledons in this stage are plano-convex, applied face to face, orbicular, entire, green, with distinct petioles, 5-nerved, with two lateral, subopposite branches from the midrib some distance below the apex. The plumule and radicle are small. The cotyledons gradually increase in size and grow over the process in which the radicle (*a*) lies, extending to the apex of the seed, doubling over and abutting against the ridge formed by the raphe and chalaza (*b*), and thus becoming more and more emarginate at the apex. The notch is therefore due to their continuing to grow at the sides after their apex has reached this ridge.

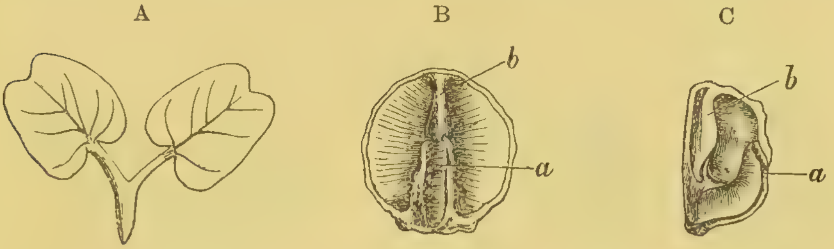

FIG. 87.—*Convolvulus Soldanella.* A, embryo, × 2. B, section of seed after removal of the dorsal surface, embryo, and endosperm, × 2. C, side view of ditto, × 2.

In Ipomœa purpurea (fig. 88, A–C), where the seed is constructed generally on the same model as in Convolvulus Soldanella, the ridge formed by the raphe and chalaza (fig. 88, B and C, *b*), is more prominent, and consequently the notch of the cotyledon is deeper. Lastly, in Ipomœa dasysperma (fig. 89, A–C) the projecting ridge of the chalaza is still more developed and reaches nearly to the process which supports the radicle; the cotyledons are thus precluded from

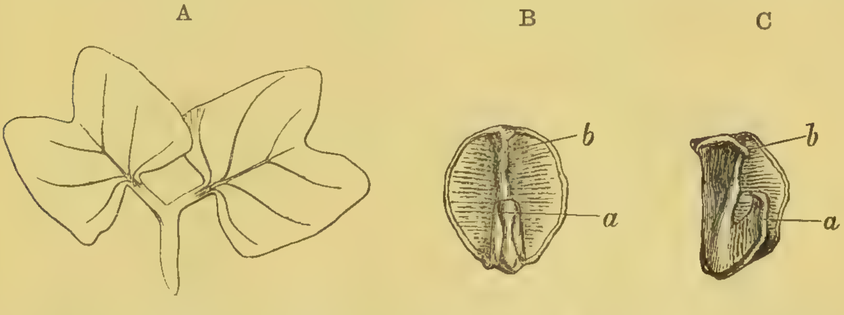

FIG. 88.—*Ipomœa purpurea.* A, embryo, × 2. B, section of seed after removal of dorsal surface, embryo, and endosperm, × 2. C, side view of ditto, × 2.

growing in length, and in consequence send out two long wings, so that they are divided almost to the base (fig. 89, A).

In Shorea, again, the division of the cotyledons is perhaps due to an internal process of the seed. I have not, however, had an opportunity of examining a specimen.

In Eucalyptus (fig. 38) we have a different case. The embryo is (with the exception of the petioles) straight or nearly so, fleshy, white, occupying the whole of the seed, and conforming to it in general outline; the cotyledons are deflexed and convolute round the radicle, which the lobes equal in length, while half of one cotyledon lies over half the other; one half of each consequently lying against the testa. The radicle is stout, fleshy, truncate at the end where it lies against the testa, but otherwise entirely enclosed by the folded cotyledons. The true length of the cotyledon is determined by the distance between the end of the petiole and the opposite pole of the seed. The side of the cotyledons, however, being folded back, that part which lies beyond the petioles is enabled by folding round the radicle to widen, and this consequently gives the cotyledons their more or less pronounced hour-glass shape.

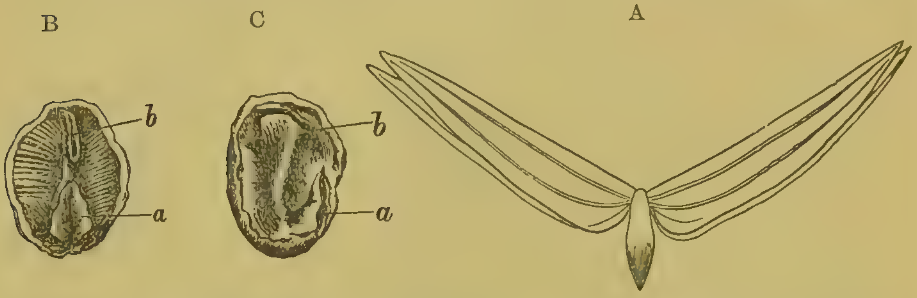

FIG. 89.—*Ipomœa dasysperma.* A, embryo, × 2. B, section of seed after removal of dorsal surface, embryo, and endosperm, × 2. C, side view of ditto, × 2.

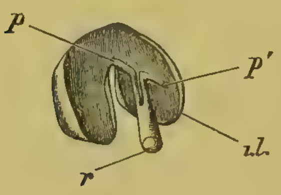

FIG. 90.—Embryo of *Eucalyptus Globulus*, one cotyledon being cut away: *p*, petiole; *p'*, cut end of petiole; *i.l*, inner lobe of cotyledon. × 4.

Moreover, in speaking of emarginate cotyledons, we must distinguish between two very opposite cases, of which I may take Galium Aparine and Œnothera Lindleyana as illustrations. In the former the cotyledons commence with an entire end (fig. 91), and subsequently, not as a rule till they have left the seed, become emarginate (fig. 92); in Œnothera Lindleyana, on the contrary, the cotyledons are at first emarginate, but gradually cease to be so. The embryo gradually appropriates all the endosperm, but the supply being largest at the wider end of the seed, this is the last part to be absorbed. In neither of these cases does the emargination appear to be directly due to the structure of the seed, nor to be in itself of any advantage to the plant. It seems rather to depend on the conditions of growth. In Galium Aparine the cotyledon terminates in a peculiar gland,[1] which would appear in this and other cases, after the emergence of the cotyledon, to stop its growth at that point, and thus to produce the emargination.

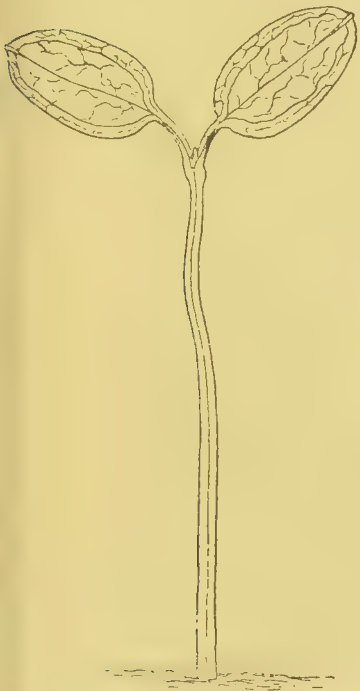

FIG. 91.—Young seedling of *Galium Aparine*, × 2.

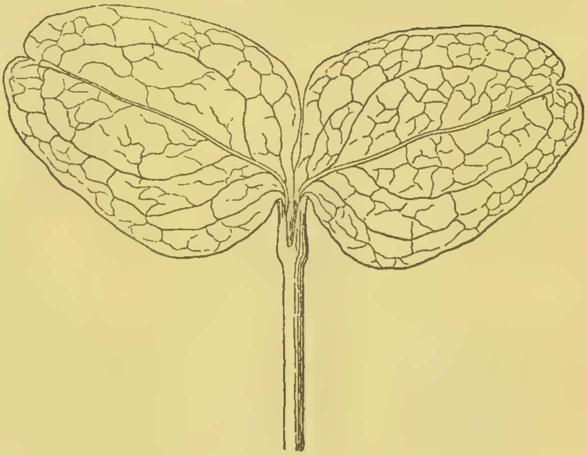

FIG. 92.—Ditto, a few days older, × 2.

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[1] This gland has already been mentioned by Gravis in his work on *Urtica dioica* (Brussels, 1886), p. 139. He observes that about a dozen small stomata occur on it, while they are entirely absent on the rest of the upper surface. He regards it as a water-gland, 'un organe destiné à remédier à l'excès de tension dans l'appareil aquifère.'

In Senecio, again, the majority of species have entire cotyledons. In some, however, as in S. erucæfolius, they are emarginate. Even here, however, they are at first entire (fig. 93), and the emargination does not make its appearance until after germination, when the cotyledons gradually become much widened (fig. 94). In fact, S. squalidus, S. viscosus, S. vulgaris, &c. have the cotyledons narrow and entire; while in S. erucæfolius and S. cruentus, where they grow more in width than in length, they become emarginate. Among other cases where the cotyledons are at first entire, but after germination become emarginate, may be mentioned some species of Lithospermum.

Bryonia laciniosa (fig. 75) also has the cotyledons emarginate, while in B. dioica (fig. 76) they are entire. They are, however, originally entire in both cases, and the emargination in B. laciniosa is due to the fact that in that species the cotyledons grow much more than in B. dioica. There is no great difference in size between the seeds, those of B. laciniosa being perhaps one-tenth larger. On the other hand, the cotyledons of B. laciniosa attain a length three times greater than those of B. dioica, as shown in the figures (figs. 75 and 76). In the genus Tacsonia, again, the cotyledons are entire in T. Van-Volxemi and T. Leschenaultii, and emarginate in T. ignea. Here also, however, they are at first entire, and only become emarginate after leaving the seed.

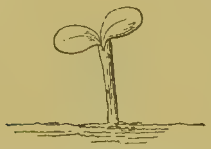

FIG. 93.—Young seedling of *Senecio erucæfolius.*

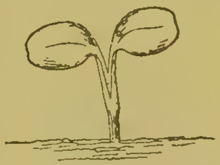

FIG. 94.—Ditto, a few days older.

DIVIDED COTYLEDONS.

The genus Pterocarya has very curious cotyledons (fig. 41), due to a cause entirely different from any of those we have considered hitherto.

They are bipartite, each primary division narrowing to a cuneate base, and being again deeply divided, so as to make in all four ultimate, linear, oblong, obtuse, entire segments. In this case the endocarp is thickened, bony, and its cavity is divided at the base into four cells (fig. 95, A, *c c c c*) by the thickening and consequent intrusion of the dorsal and ventral walls.

The seed (fig. 95, B) is conical above, deeply four-lobed below (fig. 95, B, *l l l l*), one lobe (*l*) passing into each of these cells (*c*). The embryo again follows suit, and each cotyledon sends a lobe into each of the four cells, thus assuming the peculiar form characteristic of the species.

In Eschscholtzia (fig. 40) the cotyledons are deeply bifid, resembling a hay-fork with two long prongs. In this case we find no such structure of the fruit or seed to account for the peculiarity. My first idea was that such cases might possibly be due to some difference in the endosperm, as occurs in certain Umbellifers, Delphinium, &c., and which might have permitted growth more readily in certain directions than in others. Thin sections, however, showed no such differences. Moreover, Schizopetalon Walkeri (one of the Cruciferæ) (fig. 97, A–D) has the cotyledons as deeply divided as in Eschscholtzia; and as there is no endosperm, but the embryo occupies the whole seed, within which the long lobes of the cotyledons wind about more or less irregularly, the division cannot be due to differences in the endosperm. There are, moreover, other plants, such as the Sycamore (fig. 50) and Hop, where the cotyledons are also narrow, winding, and occupy the whole seed, but are not divided. We must there-

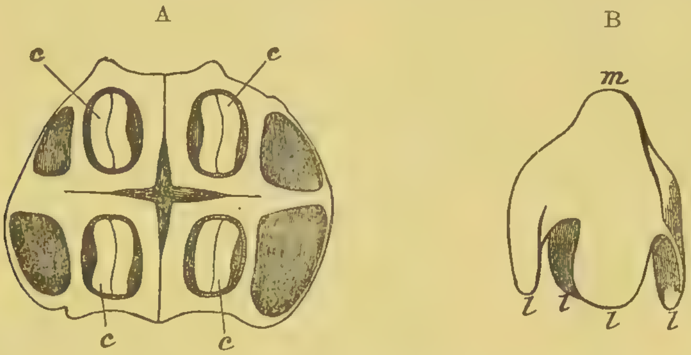

FIG. 95.—*Pterocarya caucasica.* A, transverse section of nut, × 6; showing the four hollows *c*, *c*, *c*, *c*, which are occupied by the four prolongations of the seed. B, seed, × 6.

fore seek some other explanation, and I will suggest the following.

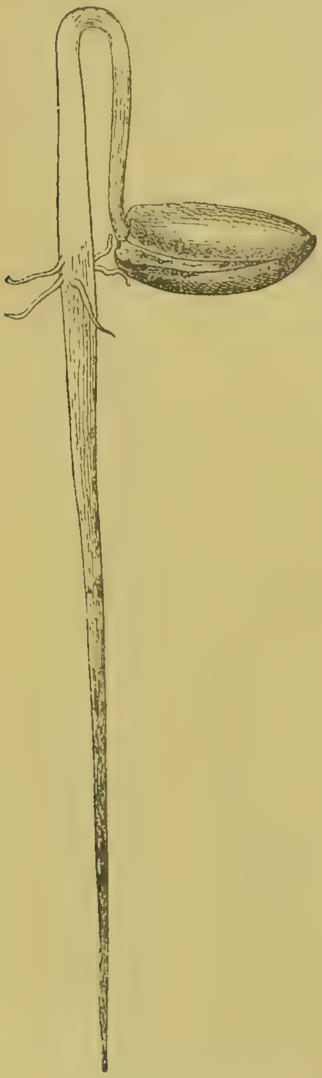

Fig. 96.—Germinating seedling of *Anona*.

In most of the species which I have examined, when the cotyledons remain in the seed they do not leave the ground. In some cases, however, as in Anona (fig. 96), the hypocotyl is long, stout, and rises in the form of a loop during germination, while the cotyledons, which at first are very small, gradually increase almost to the length and breadth of the seed, throw themselves into undulations, and, it being perhaps on this account impossible to withdraw themselves from the seed, are eventually torn from the hypocotyl. In Bignonia insignis, again, the cotyledons, though flat and leaf-like, are unable to emerge from, or at any rate do not emerge from, the seed. This may possibly give us a clue to such cases as Eschscholtzia and Schizopetalon, which, I would venture to suggest, may have reference to the manner in which the cotyledons free themselves from the seed. If this is delayed, the young plant suffers considerably, and indeed often perishes. That the process is not, however, so simple as might be imagined, may be seen from the interesting case afforded by the Cucurbitaceæ, where, in Mr. Darwin's words,[1] 'the seed-coats are ruptured by a curious contrivance, described by M. Flahaut. A keel or peg is developed on one side of the summit of the radicle or base of the hypocotyl; and this holds down the lower half of the seed-coats (the radicle being fixed into the ground), whilst the continued growth of the arched hypocotyl forces upwards the upper half, and tears asunder the seed-coats at one end, and the cotyledons are then easily withdrawn.'

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[1] *Movements of Plants*, p. 102. Bower has pointed out in Welwitschia that a corresponding process serves to absorb the endosperm, acting in fact as a feeder to the young plant (*Quart. Journ. Micr. Sci.* vol. xxi.).

May not the narrowness of the cotyledons in Eschscholtzia and their deep fission be due to a similar cause? The seed is slightly pyriform, and the radicle emerges from the narrower end. It bursts through the soil in an arch, and instead of leaving the seed-coats in the earth as usual, carries them up with it. Then the two arms of the cotyledons separate, widen the orifice, and draw themselves out.

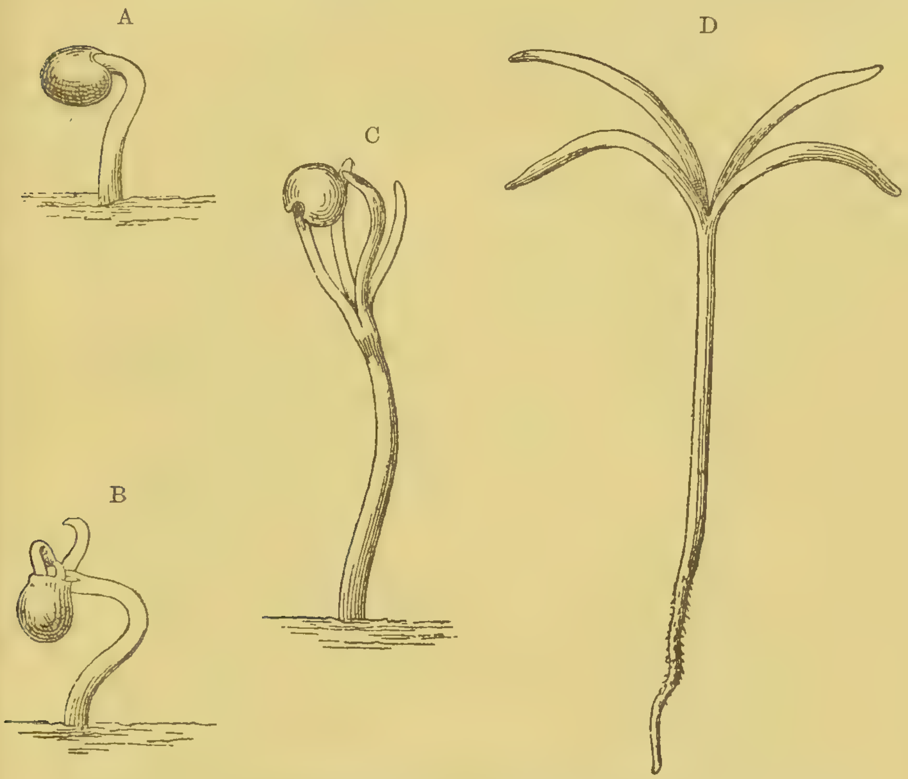

Fig. 97.—Stages in the growth of seedling of *Schizopetalon Walkeri*, × 2½.

This suggestion seems to be confirmed by the evidence of Schizopetalon (fig. 97, A–D), one of the other few cases where the cotyledons are bipartite. Here, also, the radicle emerges through a comparatively small orifice, and the seed-coats, from which the cotyledons seem to have some difficulty in freeing themselves, are carried up by the hypocotyl, while eventually the lobes of the cotyledons draw themselves out one by one. In Opuntia basilaris, again, which differs from O. Labourtiana in having narrow cotyledons, the seed-coats are similarly carried up, and the cotyledons free themselves by divergence. In this species, also, it is interesting that one or both cotyledons are often bifid. Is it possible that the multiplicity of the cotyledons in Conifers (fig. 98) can be due to the same cause?

In Ephedra there is a special membrane, which remains attached to the root, and thus prevents the testa from being carried up on the tips of the cotyledons.

The common Cress (*Lepidium sativum*) (fig. 4), to which I have already referred, is a very interesting case, for while in the other species, at any rate in the other English species, of the genus the cotyledons are entire, in Lepidium sativum, on the contrary, each possesses two long, narrow lateral lobes.

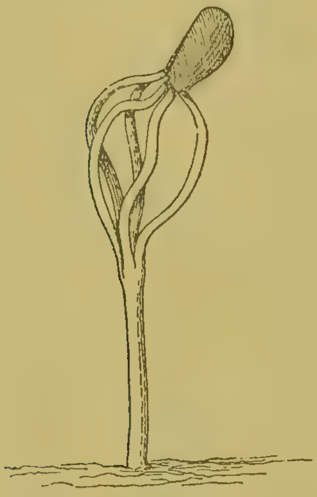

Fig. 98.—Seedling of *Pinus rigida*, × 2.

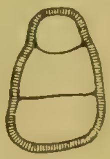

Fig. 99.—Section of seed of *Lepidium graminifolium*, × 15.

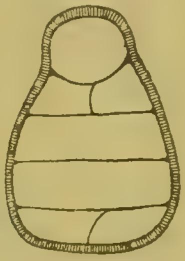

Fig. 100.—Section of seed of *L. sativum*, × 15.

Fig. 99 represents a section through the seed of L. graminifolium, which may be taken as representing the ordinary arrangement in the genus. The seeds, conforming to the shape of the capsule, are somewhat triangular, with the radicle in the narrow end. The embryo occupies the whole of the seed, there being no endosperm. In L. sativum (fig. 100) the seed is of the same form, but nearly twice as large, and if, therefore, the cotyledons were to occupy the whole additional space, they would become extremely thick. In endospermic seeds this would present no difficulty, as the additional space would be simply filled by endosperm. In Lepidium, however, this device cannot be resorted to; but the two lobes just fill up the vacancy.

In the Lime (*Tilia*) (fig. 101) we have another very interesting case.

The cotyledons are broad, foliaceous, rhomboid-subtriangular, and 5-lobed, 5-nerved at the base, with the outer and lower pair of nerves slender, alternately nerved upwards, reticulate, shining and thinly pubescent on both surfaces, deep green above, paler beneath, petiolate; lobes oblong-obtuse, with a strong nerve running into each, the outer ones always largest and sometimes ovate; middle pair of lobes always the smallest, and oblong or subulate; lamina 15–21 mm. long, 17–25 mm. from tip to tip of the basal pair of lobes; petiole semiterete, shallowly channelled above, pubescent, 6–8 mm. long.

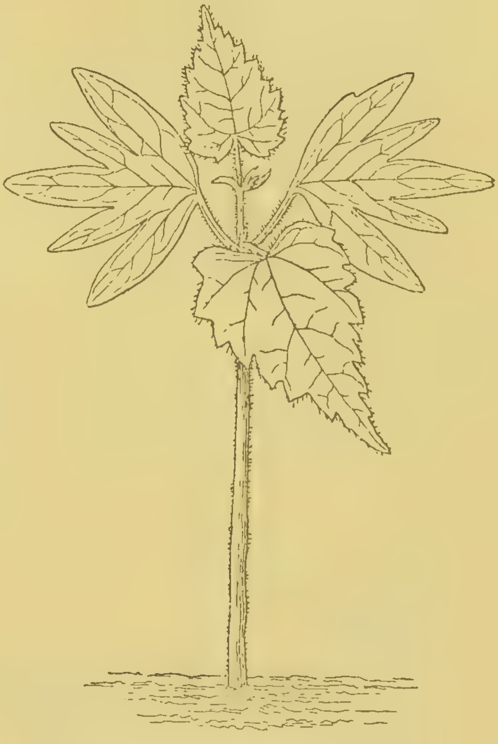

Fig. 101.—*Tilia vulgaris.* Seedling. Nat. size.

The fruit is an ovoid or subglobose nut, with five obtuse angles, tomentose with somewhat rufous hairs, one-celled by the rupture of the septa, one-seeded, indehiscent, tipped with the persistent base of the style, woody, and attached to a large deciduous bract which serves to disseminate it by the aid of the wind.

The seed is ascending or erect, obovoid or subglobose, deep brown, smooth, with a firm or crustaceous testa of two distinct layers; hilum oval, comparatively large on the ventral aspect a little above the base, and longitudinal; raphe ventral, proceeding from the hilum to the apex of the seed; chalaza apical, prominent externally as well as internally in the mature state by a deeper brown blotch; radicle inferior.

The endosperm in the mature seed is copious, firm, pale yellow, and homogeneous. There is therefore so far nothing in any way analogous to the causes which have led to the existence of the lobes in the species previously described.

The embryo is at first straight; the radicle is stout and obtuse; the cotyledons ovate, obtuse, plano-convex, fleshy, pale green, and applied face to face. They grow, however, considerably; and when (fig. 102, A) they meet the wall of the seed they bend back on themselves, and then curve round, following the general outline of the seed (fig. 102, B). If any one will take a common tea-cup and try to place in it a sheet of paper, the paper will of course be thrown into ridges. If these ridges be removed and so much left as will lie smoothly inside the cup, it will be found that the paper has been cut into lobes more or less resembling those of the cotyledons of Tilia. Or if, conversely, a piece of paper be cut out into lobes resembling those of the cotyledons, it will be found that the paper will fit the concavity of the cup. The case is almost like that of our own hand, which can be opened and closed conveniently owing to the division of the five fingers.

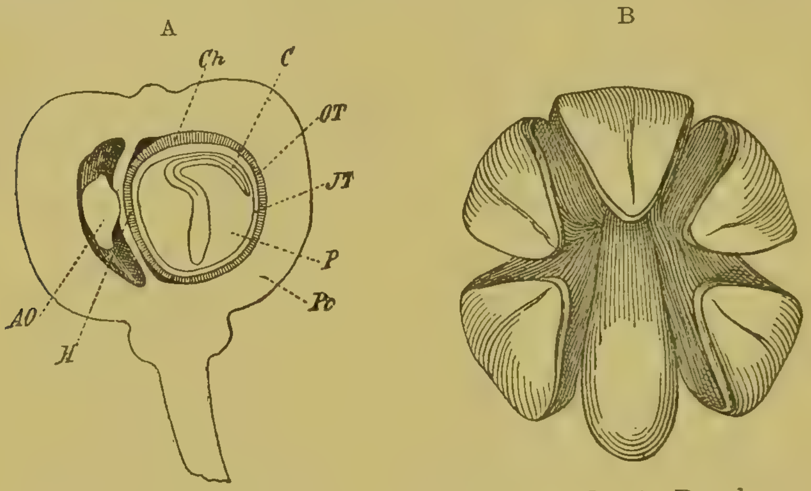

Fig. 102.—*Tilia*. A, section of seed, × 4. B, embryo, × 8.

It may be said that the seed of the Sycamore (*Acer*) is not very dissimilar in form to that of the Lime (*Tilia*); and yet the cotyledons are long, narrow, and strap-shaped, while those of the Lime are rhomboid and five-lobed; but it must be remembered that in the Sycamore the embryo occupies the whole seed, while in the Lime it is embedded in endosperm.

The peculiar lobed form of the cotyledons of Tilia thus enables them, I would suggest, to lie conveniently in the globose seed.

AURICLED COTYLEDONS.

Some cotyledons are markedly auricled. As illustrations I give Poterium (fig. 42) and Hakea (fig. 21). This form is, I am disposed to suggest, a provision to fill up vacant space in the seed. In the seed of Hippophaë (fig. 53) the form of the cotyledon leaves at each side of its base two spaces (*d*), which are occupied by endosperm. In Cuphea (fig. 84), Ruellia (fig. 55), and Poterium (fig. 83), on the other hand, there is no endosperm, and it is consequently an advantage that the cotyledon should develop auricles in order to fill up the space.

If this is the explanation of the auricles, we should expect to find them developed principally in families where the endosperm is deficient. Now in the species I have examined, auricled cotyledons occur in 35 genera, belonging to 22 families, of which 13 have no endosperm, while in 6 of the 9 others it is reduced almost to a film.

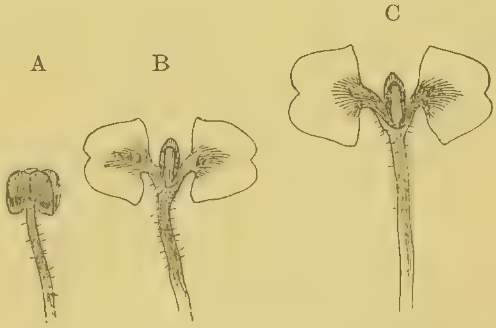

FIG. 103.—Three stages in the growth of the seedling of *Cuphea silenoides*.

The argument in the case of Cuphea is further strengthened by the peculiar conformation of the radicle (fig. 84), which is three-lobed, the reason being, I would suggest, that the radicle co-operates with the cotyledons in the endeavour to fill up the vacant spaces.

In support of this view I also would observe that the auricles seem to be of little use to the young plant. For instance, the embryo of Cuphea, while in the seed (fig. 84) has very large auricles, which in the seedling (fig. 103, A–C) soon disappear. In Ruellia, again (fig. 55), we have a similar case.

Size of Seeds.

As regards the size of seeds, if we could imagine a state of things in which every seed grew and attained maturity, then to keep up the number of any given species existing at any time, it would be sufficient if each plant produced but one or two seeds during its whole life. There is, however, an enormous destruction of seeds. The great majority are eaten by animals, or fail to secure a suitable site for germination ; of those which do germinate, again, many are crowded out by their fellows. Darwin observed that out of 357 seedlings which came up in a space of 3 feet by 2, no less than 295 were destroyed by slugs and insects. Now the greater the chance against any given seed reaching a suitable locality and attaining maturity, the larger number of seeds must the plant produce in order to maintain its numbers, and, as a general rule, the smaller will the individual seeds be. On the contrary, the greater the chance that each seed enjoys of arriving at maturity, the smaller the number of seeds that is necessary, and in such cases it is an advantage that the seeds should be large.

Hence parasitic plants generally produce a large number of very small seeds, though there are exceptions due to other considerations, as, for instance, in the Mistletoe (I believe, indeed, in all the Loranthaceæ), where the seeds are carried by birds.

An interesting illustration is afforded by certain species which produce two kinds of pods, as, for instance, Cardamine chenopodifolia of Brazil. Besides ordinary pods, which resemble those of any other Cardamine, and contain several seeds, this plant produces a second sort of pod underground. Now in the ordinary pods the number of seeds increases, of course, the chance that some one will find a suitable place. On the other hand, the subterranean pods are sown, as it were, by the plant itself. In this case, if there were a number of seeds they would only get in one another's way, and hence, perhaps, the fact that the subterranean pods only produce one or two seeds.

In most species the seeds vary somewhat in size; but in such cases it would not be conclusive to contrast the produce of large seeds with that of smaller ones, because it might fairly be said that the former were better nourished, and inherently, perhaps, more vigorous. In Cardamine chenopodifolia of Brazil, however, the seeds from the underground pods are larger than the others, and Grisebach found that they produced more vigorous seedlings.[1]

There are, on the contrary, other considerations which may make it an advantage that the number of seeds produced by a flower should be reduced, as, for instance, in the case of the Compositæ, where the agglomeration of a number of flowers into a single head, as in the Daisy, and their consequent diminution in size, renders it an advantage that each floret should produce but one seed.

The species with large seeds may, as already mentioned, be divided into two groups—first, those in which the embryo is surrounded by endosperm; and, secondly, those in which it occupies the whole seed.

In the former the arrangement of the embryo presents no special difficulties, as the endosperm simply fills up all vacant spaces. In the latter, on the contrary, Nature has to exercise much ingenuity, and adopts various devices to fill up the whole space.

One plan is to arrange the cotyledons face to face, and then roll them up in a ball. This is adopted, amongst other cases, in the Sycamore (fig. 50), and hence the long strap-like form of the cotyledons. Another is to arrange the cotyledons face to face, and then double them up, as in the Cabbage, Mustard, Radish (fig. 62, B–D), &c.

In a third the cotyledons are convolute edgeways, as in Calycanthus.

In Lepidium sativum the cotyledons are trifid (figs. 4 and

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[1] 'Der Dimorphismus der Fortpfl. v. Cardamine chenopodifolia,' *Göttinger Nachrichtungen*, 1878.

100); in Cordia they are thrown into plaits (fig. 70). In others we have still more complex folds, as in the Beech.

In such cases as the Lupine the cotyledons become so fleshy and thickened that they almost lose the appearance of leaves; in this instance they are set free by the splitting of the testa. When, however, the testa does not readily split, and where in large seeds there is no endosperm, the difficulty of unfolding the cotyledons and extricating them from the seed becomes greater, and we arrive at cases where Nature seems to have abandoned the attempt, and, as in the Oak and Horse Chestnut, the cotyledons never quit the seed. Thus, among the Juglandeæ, Pterocarya has leaf-like cotyledons, while those of the Walnut never quit the shell. Every one, however, must have observed the elaborate folds into which the two cotyledons are thrown—folds which seem to have no significance or importance now, and which carry us back to a time when the Walnut, like the Pterocarya, had foliaceous cotyledons.

If these suggestions be correct, we should expect that species with non-emerging cotyledons would generally have large seeds and be exalbuminous. This certainly appears to be the rule; among the species with reference to which I have notes, there are 37 genera in which the cotyledons are subterranean or remain in the seed. The seeds themselves are notably large, and all but three are exalbuminous. Occasionally we meet with subterranean and foliaceous cotyledons in the same genus, as, for instance, in Rhus, Rhamnus, Mercurialis,[1] Phaseolus, &c.

Phaseolus vulgaris presents us with an intermediate stage, the cotyledons being aerial and green, but fleshy and by no means true leaves. In Melittis melissophyllum, again, according to Irmisch,[2] the fleshy cotyledons generally remain in the seed, and are held together by the testa: but they sometimes burst the shell, and stand out from one another. Like true subterranean cotyledons, they have no stomata.

When the cotyledons are large, thick, and fleshy they often contain sufficient nourishment to render the plants for some time independent of any fresh supply. In such cases the seedlings sometimes push up for awhile without any fully-developed leaves, the first few being reduced to very small size or almost obsolete, as in Rhus (fig. 44), Sapindus (fig. 43), Tropæolum, Bertholletia, Camellia, Xanthochymus, Calophyllum, Calodendron, Ochna, Citrus, Corylus, &c.

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[1] Winkler, *Flora*, 1880, p. 339.

[2] 'Zur Naturgeschichte von Melittis Melissophyllum,' *Bot. Zeit.* 1858, p. 233.

SIZE OF EMBRYO.

As already mentioned, there are many cases, in fact many whole orders, in which the ripe seed is entirely occupied by the embryo; in other cases, again, as in Delphinium (fig. 104), the embryo is very small, and examples of every intermediate stage might be given.

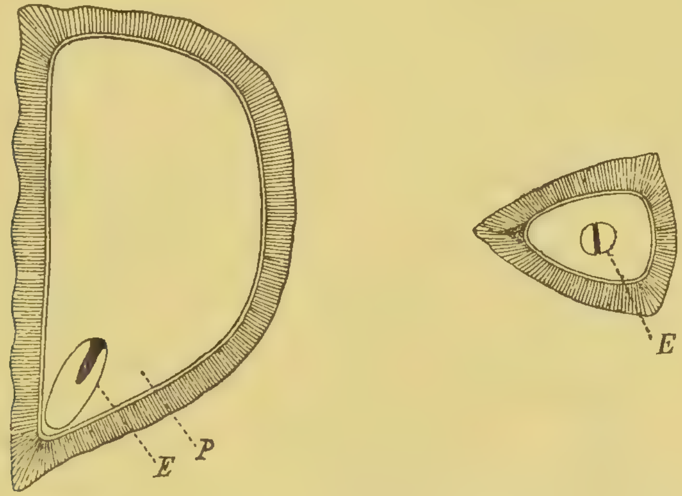

FIG. 104.—Longitudinal and transverse sections of seed of *Delphinium Staphysagria*, × 12.

Where it is an advantage to the plant that germination should be rapid, this of course can be more readily secured if the embryo is large. In fact, we find that species with large embryos, such, for instance, as Cabbage, Pea, &c., germinate much more rapidly than those, such as Umbellifers, Ranunculaceæ, &c., in which the embryos are small.

On the other hand, in some cases, time is less important, and here other considerations come into play. The protection of the embryo is mainly effected by the outer coverings; but the endosperm itself contributes also,[1] and hence a small embryo is less liable to injury.

Size of Cotyledons.

It is hardly necessary to say that the size of the plant does not determine that of the cotyledons. Winkler has pointed out that the largest of our Nettles has the smallest cotyledons.[2] It is, on the other hand, natural that large seeds, as a general rule, produce large cotyledons. This is, however, by no means a complete explanation. There are many cases in which the cotyledons grow considerably after quitting the seed. In the wonderful genus Welwitschia it was at one time supposed that the two great leaves were persistent cotyledons. This view is now abandoned. In many of the Monocotyledons, however, the cotyledons acquire a considerable length. I have already had occasion to allude to cases among the Dicotyledons in which the cotyledon continues to grow for some time after quitting the seed.

Streptocarpus Rexii affords, perhaps, the most remarkable case. The cotyledons are at first small, rotund, and shortly petiolate. Soon, however, one of them begins to grow, and becomes an at first ovate, then oblong, and finally panduriform, obtuse, entire, persistent leaf, attaining a length of more than 18 inches. The other cotyledon retains the original form, and soon drops off. In some specimens, however, both cotyledons retain their original form, and it is the first true leaf which develops.

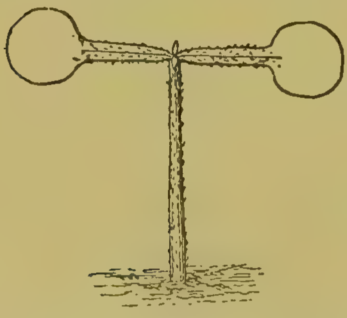

Fig. 105.—Seedling of *Œnothera bistorta*, × 3.

In the cultivated form of the Mango, the cotyledons are divided into more or less irregular lobes; and in a specimen kindly given me by Mr. Ridley, one of the lobes developed into an independent plant.

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[1] See Marloth, 'Ueber Mech. Schutzmittel der Samen gegen schädliche Einflüsse von Aussen,' Engler's *Bot. Jahrb.* 1883, p. 225.

[2] 'Ueber die Keimblätter der deutschen Dicotylen,' *Verh. Bot. Ver. Brandenburg*, 1874, p. 11.

Some of the Onagrarieæ have seedlings with very curious cotyledons. For instance, I was greatly puzzled by the seedling of Œnothera bistorta, in which (fig. 105) the cotyledons were long and linear, suddenly widening at the end into a large orbicular expansion, which gives them a very peculiar appearance.

In Eucharidium grandiflorum (fig. 108) the form of the cotyledon might not unnaturally be supposed to be a case similar to that of Malva. In reality, however, the explanation is very different. In Eucharidium the lobes have nothing to do with the arrangement of the embryo in the seed. The young plant, indeed, immediately after germination, presents no trace of them. The cotyledons, when they first emerge from the seed (fig. 106), are oblong-orbicular, sessile, cordate or auricled at the base, and emarginate at the apex, with a small purple tooth in the notch: they grow rather rapidly, become shortly petioled, and develop one or two lateral, incurved nerves on each side of the midrib.

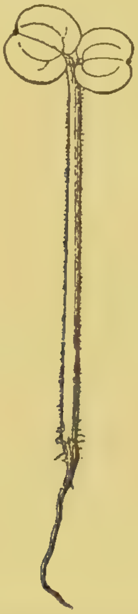

Fig. 106.—Seedling of *Eucharidium grandiflorum*, × 3.

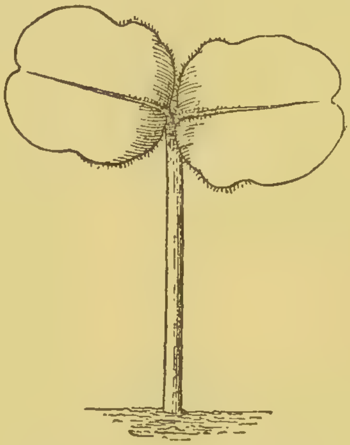

Fig. 107.—*Eucharidium grandiflorum*: ten days after germination, × 3.

In the next stage, about eight days after germination, they exhibit a very slight constriction near the base of the cotyledons, with a small obtuse tooth. This basal portion increases much more rapidly, while the growth of the terminal portion (which is, in fact, the original cotyledon) becomes gradually arrested. The tooth becomes more marked (fig. 107), and by the tenth day the new portion is obtusely bidentate or crenate, and nearly equals the original cotyledon in size.

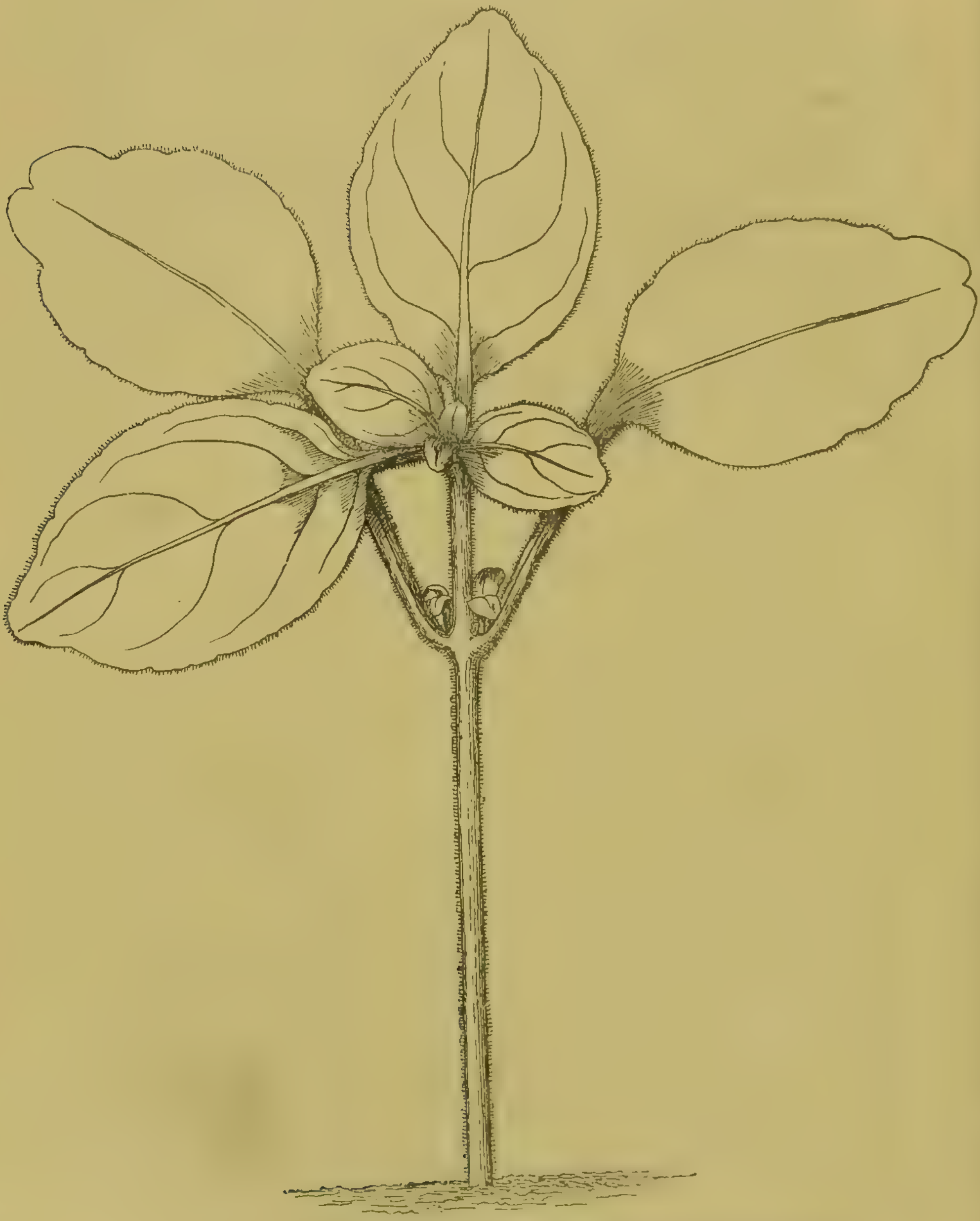

Fig. 108.—*Eucharidium grandiflorum*: showing final form of cotyledons. Nat. size.

In its final form (fig. 108) the new portion is both broader and longer than the true cotyledon, and differs from it not only in the crenations, but in the possession of a more conspicuous midrib and rather stiff hairs. Not only is this basal portion interesting in its mode of development, but also from its similarity to the subsequent leaves. In fact, as fig. 108 shows, it may be said that we have a compound structure formed of a leaf at the base, terminated by the cotyledon.

If, indeed, this species stood alone, we might regard the resemblance as accidental; but we find a very similar growth in other allied species.

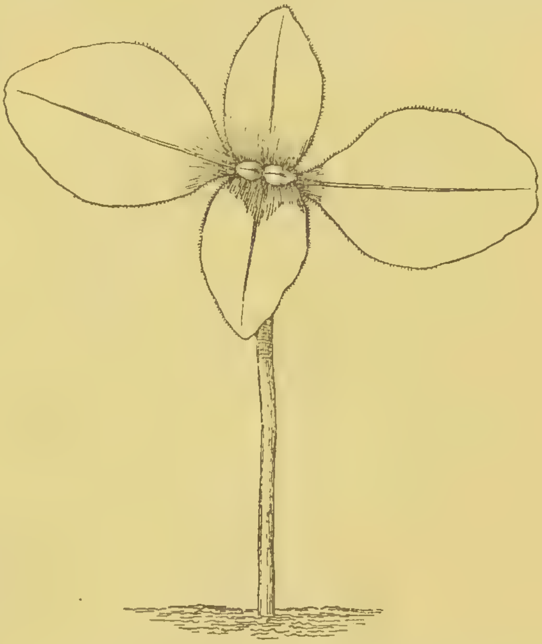
FIG. 109.—*Clarkia pulchella.* Two-thirds nat. size.

In Clarkia pulchella (fig. 109) the cotyledons immediately after germination closely resemble those of Eucharidium grandiflorum (fig. 106). In a short time they become broadly ovate, emarginate, suddenly narrowed, and rounded at the base. In this case there is no great change of form; but while the margin of the original cotyledon is glabrous, that of the new growth and of the true leaves (fig. 109) is finely ciliate.

In Œnothera stricta the cotyledons immediately after germination are oblong, obtuse, slightly auricled at the base, otherwise entire, sessile, thinly glandular-pubescent on the upper surface, and ciliate. By continued intercalary growth at the base they eventually become (fig. 110) spathulate, obovate or oblong-obovate, obtuse, with a tooth on each side, indicating the point of union of the original cotyledon and the new growth; the lower part with a distinct midrib and tapering much at the base, glabrous, with puberulous-pubescent petioles, connate at the base.

The first leaves are alternate, lanceolate, obtuse, tapering to the petiole, obsoletely and distantly toothed at the margins, and, like the cotyledons, are glabrous with pubescent petioles.

Similar instances have been observed in many species of Clarkia and Œnothera, and will be fully described in the chapter on Onagrarieæ.

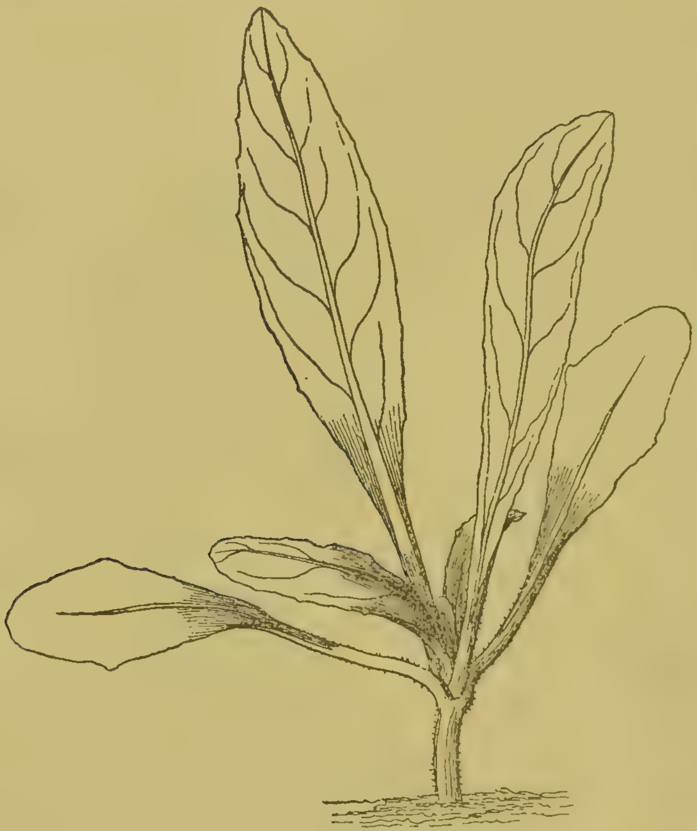

Fig. 110.—*Œnothera stricta*, thirty days after germination. Nat. size.

Here, therefore, we have an interesting group in which at first the cotyledons are very similar, but by subsequent growth at the base develop into several distinct types, in each case closely resembling the leaf characteristic of the species. We can therefore have little, if any, doubt that this growth is influenced by the form of the leaf.

The species in which a connection may perhaps be traced between the characteristics of the leaves and those of the cotyledons are so few, that I may mention here that of Embelia Ribes (fig. 111). The leaves are simple, alternate, exstipulate, petiolate, alternately incurvinerved, rather thick and indistinctly reticulate, shining on both surfaces, bright green above, paler beneath, and punctate with dark green sunken glands eventually becoming black, thinly glandular-pubescent on both surfaces; petioles semiterete, channelled above, closely glandular-pubescent, tapering downwards. The first leaf is broadly ovate, or short-elliptic, acute, and serrate except towards the base. The second is similar, but less broad; the third, fourth, and fifth lanceolate, each rather narrower than the preceding.

The cotyledons are ovate, obtuse or subacute, indistinctly alternately incurvinerved, and reticulate, distantly serrate in the upper half, petiolate and tapering into the petiole, glabrous, bright green and shining above, paler beneath, thinly glandular on both surfaces, and dotted with sunken black glands; petioles semiterete, slightly furrowed above, finely glandular-pubescent. Here it will be observed that the cotyledons are strikingly like the first leaves; and, moreover, that there is a regular gradation from the broad ovate cotyledon to the final leaves, which are narrow lanceolate. The serration of the cotyledons is a very rare character, which makes the resemblance in this respect all the more significant.

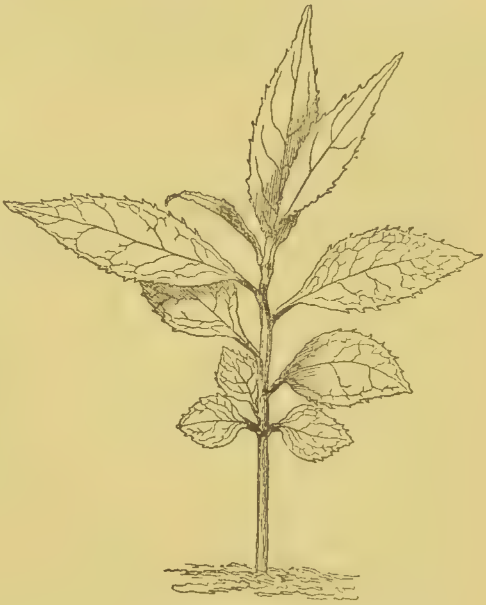

FIG. 111.—Seedling of *Embelia Ribes*. Half nat. size.

In this connection also I may perhaps mention Eschscholtzia tenuifolia. I have already described[1] and figured (fig. 40) the germination of E. californica, in which the cotyledons are long, narrow, and deeply bifid, and suggested that this form

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[1] Vide *supra*, p. 49.

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enabled them more easily to make their exit from the seed. In that species, where the cotyledons are deeply bifid, the leaves also are much cut up. In E. tenuifolia, on the contrary, both the leaves and cotyledons are long and linear. Here also the form probably facilitates the exit; and one may perhaps suggest that E. californica exhibits a form of which E. tenuifolia represents an earlier and simpler condition.

POSITION OF THE EMBRYO IN THE SEED.

As a general rule, the arrangement and position of the embryo in the seed is approximately the same within the limits of any one genus. There are, however, many exceptions.

In the genus Plantago, for instance, the cotyledons sometimes have their faces and sometimes their edges to the placenta. This difference is not indeed mentioned either by Barnéoud or Decaisne in their respective monographs of the family. Bentham and Hooker, however, say ('Genera Plantarum,' vol. iii. p. 1223):—'Embryo rectus v. rarius hippocrepicus, hilo parallelus v. in fructu monospermo erectus v. transversus.'

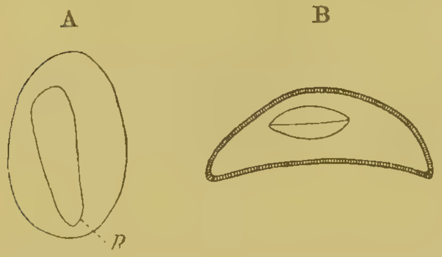

FIG. 112.—*Plantago media.* A, longitudinal section of seed, ×8. B, transverse section of seed, ×8.

In P. media the fruit is capsular, dry, membranous, 2-celled and 2–4-seeded. The seeds (fig. 112, A and B) are plano-convex or subconcavo-convex, peltate, small, with equal obtuse ends; or with the basal end slightly the broader; the testa is thin, pale brown; the hilum a little below the middle on the ventral aspect, round, and deeper brown than the rest of the testa; the raphe tapers from the hilum obliquely towards the upper end of the testa. The endosperm is copious, fleshy, and white. The embryo is straight, narrow, white, a little shorter than the endosperm, and embedded in it, a little nearer the dorsal aspect of the seed and somewhat oblique to the median axis; the cotyledons are linear-spathulate, tapering towards the base, obtuse, entire, and with their faces towards the placenta; the radicle is inferior, obtuse, and shorter than the cotyledons.

In P. lanceolata (fig. 113) the capsule is also 2-celled, with one seed in each cell. The seed is concave on the ventral side, at first pale green, at length becoming yellow. The hilum is oval, forming a white or pale spot about or a little below the middle on the ventral aspect. The endosperm is abundant, fleshy, or almost horny when dry, and semitransparent. The embryo is straight, white, embedded in the endosperm, and a little shorter than the seed. The cotyledons are narrowly oblong or linear, obtuse, plano-convex, closely applied face to face, and with their edges to the placenta. The radicle is narrower than the cotyledons, inferior, and tapering downwards.

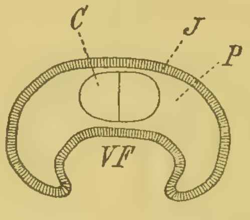

Fig. 113.—*Plantago lanceolata.* Transverse section of seed, × 12.

In P. Coronopus the capsule is many-seeded. The seeds are oblong-oval, suddenly tapering to an obtuse point at the lower end, small, in transverse section somewhat diamond-shaped, with the angles rounded off, and attached to the placenta considerably below the middle. They are much smaller than those of P. media, and differ much among themselves. The embryo is comparatively large, straight, central, nearly equalling the endosperm in length; the cotyledons are linear obtuse, entire, plano-convex, thick, closely applied face to face, and with their edges to the placenta.

In P. maritima the fruit is narrowly ovoid, 2-celled, 2-seeded. The seed is oblong-lanceolate, biconvex or flattened on the ventral side. The embryo is straight, large, and nearly fills the seed; the cotyledons have their edges to the placenta.

In P. Cynops the fruit is green, with a pale line where the two carpels come together, and a darker one along the middle of the carpel, giving it in a young state the appearance of consisting of four carpels, 2-celled, 2-seeded. The seed is ovate, obtuse, peltate, compressed dorsally, concave on the ventral side, smooth, shining, deep green when young, and sufficiently transparent to show the embryo by transmitted light. The embryo is straight; the cotyledons linear, obtuse, entire, closely applied face to face, with their edges to the placenta.

In P. arenaria and P. major the cotyledons are also placed with their edges to the placenta.

I was for some time much puzzled as to why the cotyledons in P. media should be placed differently from those of the other species examined; though the reason seems in reality very simple. At first I thought it might have reference to the mode in which the embryo emerges from the seed; but this does not seem to have any bearing on it. In P. lanceolata, however, and its allies the cotyledons are narrow and thick; and the seed being somewhat compressed, it will be seen from fig. 113 that if the embryo had been placed with the faces of the cotyledons to the placenta, it would not have had room to develop.

On the other hand, in P. media (fig. 112) the reverse is the case: the cotyledons are thin and comparatively wide; their width, in fact, is greater than their thickness. It follows that, if they had been arranged as in the other species, they would not have had room to develop. The difference of position is therefore explained by the fact that in P. media the width of the cotyledons is greater than the thickness; while in P. lanceolata &c., on the contrary, the thickness of the two cotyledons, taken together, is greater than their breadth.

The normal arrangement of an embryo in the seed is to have the faces of the cotyledons turned to the placenta. There are, however, not a few cases in which, as in these species of Plantago, the cotyledons have their edges to the placenta. When this is the case, it may be suggested as possible that the position is due to the fact of the seeds being more or less, in some cases very much, flattened; and that the embryo is twisted round at right angles to its normal position, so that the cotyledons may lie in the broad way of the seed, as in Ailanthus, Euonymus, Passiflora, Linum, Fraxinus, Diospyros, Heliotropium, and many Crucifers, Leguminosæ, and Rosaceæ.

On the other hand, in the case of Claytonia (fig. 114) this explanation will not apply. There would appear no reason, so far as the seed is concerned, why the cotyledons should not lie in the usual position.

It has occurred to me that perhaps the arrangement of the cotyledons may have reference to their exit from the seed. If we examine a germinating seedling of Claytonia, we shall see that the testa splits vertically from the micropyle, and the cotyledons from their position, when they separate, act with greater advantage in enlarging the orifice, and thus securing their exit, than they would if they occupied the more usual position. This, however, I only throw out as a suggestion which requires further investigation.

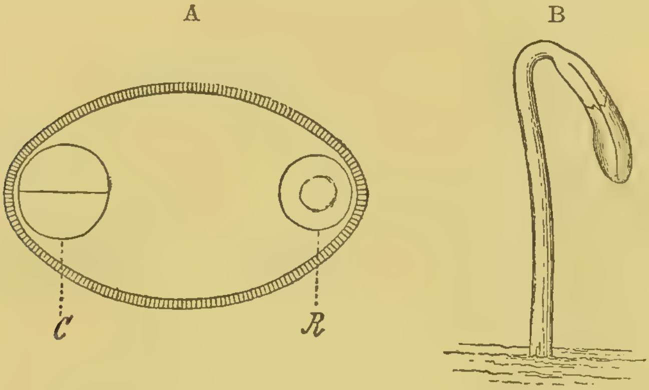

FIG. 114.—*Claytonia perfoliata.* A, transverse section of seed, × 15. B, seedling, × 6.

When the seed is flattened laterally, the embryo must either be narrow or lie with the edges of its cotyledons to the placenta.

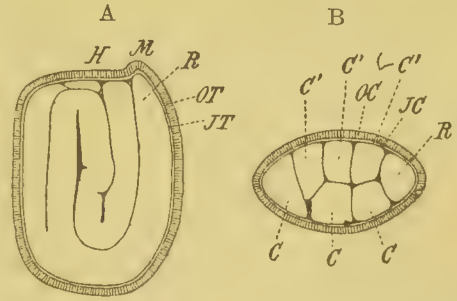

FIG. 115.—*Heliophila pilosa.* A, longitudinal section of seed, × 12. B transverse section of seed, × 12.

For instance, in Heliophila pilosa *var.* incisa the seeds (fig. 115, A and B) agree closely in form with those of Cheiranthus (*C. Cheiri*) (figs. 73 and 74); they are oblong-obtuse at each end, compressed dorsally, with a notch at one end, and in section are narrow elliptic; but while the cotyledons of Cheiranthus are broad, in Heliophila they are long and linear. The reason of this may be that while in Cheiranthus and other Arabideæ the pods are flattened dorsally and the cotyledons are accumbent in the broad way of the seed (figs. 73 and 74), those of the Sisymbrieæ, to which Heliophila belongs, have (fig. 115, A and B) the cotyledons incumbent, so that they lie across the seed, and it is consequently an advantage that they should be linear.

Similar cases occur in other Orders, as for instance in Caryophyllaceæ and Solanaceæ.

Concluding Remarks.

The conditions under which the seedlings are grown naturally exercise some influence on the form of the leaves. For instance, in Mimulus luteus, if the seedlings have sufficient room the first leaves are shortly stalked and deltoid, while the primary nodes are but little developed ; on the contrary, if they are more crowded, the internodes and petioles are longer and the leaves are oval.

In the Primrose we find an arrangement which almost seems as if it were intended to give the seedling some power of locomotion. The hypocotyl is sometimes horizontal, and throws out strong adventitious roots, the upper part, however, becoming vertical as usual.

As a general rule, the first buds produced by the seedlings are in the axils of the leaves, or more rarely of the cotyledons. In some species of Linaria, however, the hypocotyl itself throws out one or more buds which develop into branches. The advantage of this may be that, if the main shoot is cropped or broken even down to the root, the plant is capable of throwing up another stalk.

We thus find an almost inexhaustible series of beautiful adaptations to purpose. On the other hand, there are not wanting cases in which it would seem that the adaptation is not complete, or that a certain change, which has been of superior importance, has involved a minor evil.

The Oak, Beech, Nut, &c. afford us a very interesting series of species. Fig. 117 represents a diagram of a Nut with the parts somewhat separated from one another, so as to show the relations more clearly. The mycropyle (*m*) is at the apex of the seed. The ovule, however, is not straight and orthotropous, which would be, or at any rate seem to be, the simplest arrangement. Quite the contrary, for we find a long placental axis (*pl*) which extends to the apex of the nut, and from which starts a raphe (*r*), which returns about half way back again to the place where the true attachment or chalaza (*ch*) is situated. I have in vain endeavoured to discover or imagine any circumstances which would render this complex arrangement specially adapted to present conditions. It would seem as if it would be simpler and give Nature less trouble if the ovule sat directly with its base on the stalk, thus doing away with both the placental axis (*pl*) and the raphe (*r*).

This view is strengthened by the fact that such an arrangement has been in fact nearly attained by the Oak. The ovule in this genus is theoretically anatropous, but the placental axis and the raphe are both greatly shortened (fig. 116), so that the distance which the nourishment has to traverse is much less, though the actual place of attachment remains the same. The Oak in fact seems to have appreciated the difficulties of the situation, and to have in great measure neutralised them. Is it fanciful to imagine that some ages hence the Oak may be practically orthotropous?

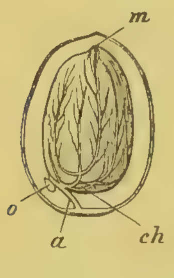

FIG. 116.—Seed of Oak (*Quercus pedunculata*). Nat. size. *o*, abortive ovule.

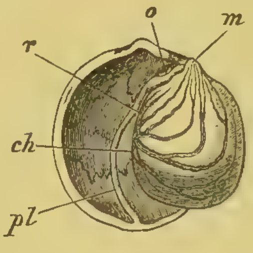

FIG. 117.—Seed of Nut (*Corylus avellana*). Nat. size. *o*, abortive ovule.

But why should these species be anatropous if it is an advantage to be orthotropous? On this question some light is thrown by the fact that while one seed only comes to maturity, the ovary contains originally several cells each with one or two ovules, though none of the others come to anything. They can, however, easily be seen, either at the apex of the seed, as in the Nut (fig. 117, *o*), Beech (*Fagus*), &c., or, as in the Oak (fig. 116, *o*), near the base. Their presence appears to indicate that these species are descended from ancestors the fruit of which was composed of several cells, each with more than one seed—a state of things therefore very unlike the present, and when the anatropous condition would be an advantage. If this view be correct, the structure of the fruit in the Nut, Beech, &c. becomes peculiarly interesting, because it represents a case in which the present arrangements are not those in all respects most convenient to the plant, and renders it probable that the same explanation may apply to other cases of difficulty.

We meet indeed with a great many cases in which a larger or smaller number of the ovules, often all but one, fail to become developed. In some of them we may perhaps see a provision to increase the chances of fertilisation. There are others, however, in which this explanation will not hold good. In Ptelea, for instance, the ovary contains 2–3 cells, each containing two ovules, one inserted rather above the other, and the inferior ovule constantly fails to develop. In this and other similar cases we can hardly doubt that the existence of this second, and now functionless, ovule carries us back to a time when the ancestors of our present Ptelea habitually produced two seeds.

In Paliurus the fruit normally contains three, but sometimes only two, loculi, each with a single seed. Again, in Myagrum the ovary is spuriously 3-celled, but the two outer cells produce no seed. In Hæmanthus there are three cells, each containing a seed, only one of which, however, comes to maturity. In Convallaria there are three cells, each with two ovules, but only one of the six is generally developed. In Phillyrea and Canarium there are two ovules, only one of which is developed; and we meet with similar cases in Gyrinopsis, Jasminum, Æsculus, Cordia, and many others.

From the point of view as to the origin of these differences, the variations in seedlings offer great interest. For example, out of 135 seedlings of Lepidium sativum (which, as already mentioned, differs from the rest of the genus in having tripartite cotyledons), no less than 25, or as much as 18½ per cent., differed from the type, and had this character more or less imperfectly developed. Under cultivation the seedlings of Primula sinensis often have one of the cotyledons deeply bifid; in one lot of seedlings this was the case with, for instance, over 20 per cent. of the plants.

In Poterium Sanguisorba the calyx-tube generally contains one, but sometimes two or even three achenes. In Ranunculus, occasionally, the petioles of the cotyledons are connate.

In Œnothera the cotyledons are either straight, or with one or both involute. Irmisch states that the cotyledons of Clematis recta, which are usually aerial, sometimes remain below ground; while the reverse is the case in Melittis, and, according to Winkler, in Dentaria and Mercurialis, for the cotyledons, which are generally fleshy and subterranean, sometimes rise above ground and form small green leaves.

Many species occasionally have one or both cotyledons divided.[1]

In Rheum the cotyledons are generally parallel, but in some cases one of them is placed more or less obliquely with reference to the other.

In Fagopyrum the position and arrangement of the cotyledons in the seed vary greatly. The cotyledons are turned about after striking into an angle of the seed, and then, following the testa, assume very various positions. In Carum Carui the cotyledons sometimes have their backs to the axis of the fruit, and sometimes their edges, while at others they are oblique.

In Cheiranthus pygmæus the cotyledons are said to be sometimes accumbent, sometimes incumbent, and straight or convolute, even in the same pod.

It would be easy to multiply such cases, but I will only mention one more, in which I will venture to suggest a reason for the variation. In Acer (fig. 118, 1), the embryo originates in a short tubular cavity opposite the micropyle, and is at first straight, with an extremely short turbinate radicle, and ovate, obtuse, closely adpressed cotyledons. As growth continues the embryo extends itself along the lower side of the seed, and curves with it, becoming gradually lanceolate, or oblong-lanceolate (fig. 118, 2). When the cotyledons have reached the upper, narrow end of the seed, the curvature of the wall turns them down again on themselves (fig. 118, 3). This growth is continued until the tips reach the radicle again, and the ultimate arrangement of the embryo differs according to whether they then curve inwards or outwards. This, again, seems to depend on the exact direction of the growth of the cotyledons. If they strike (fig. 118, 5) against the process which encloses the radicle, then their general direction naturally carries them outwards, until the wall of the seed again turns them upwards, so that they become plicate; if, on the contrary, the tips of the cotyledons pass just within the micropylar process and touch the radicle, then they are compelled to grow in the opposite direction, and they become spirally coiled. In the specimens examined the latter arrangement was exceptional.

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[1] See Goebel, *Grundzüge Syst. Spec. Pflanzen-Morphologie*, p. 505; or Eng. trans., *Outlines of Classification* &c. p. 446.

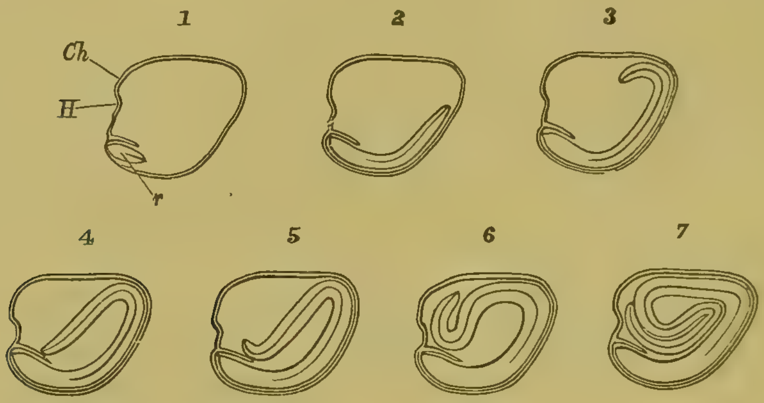

Fig. 118.—*Acer Pseudo-Platanus*. Sections of seed in seven successive stages, showing growth of embryo, × 3.

Forms of the First Leaves.

Some particulars with reference to the first leaves and the transition between them and those of the final form will be found in the following pages. I will only here observe that the first leaves are generally simple, or at any rate simpler than those which follow.

In species with trifoliate leaves, the first leaf is generally simple, as in the Clovers. When the mature leaves are pinnate, the first ones are generally trifoliate; and when the final leaves are bipinnate, the first ones are generally pinnate. I have already observed that species with lobed or palmate leaves often commence with one or more which are entire and heart-shaped.

In most cases, therefore, the first leaves are simpler than those which follow. In species from very dry localities, however, the reverse is often the case. For instance, in Lasiopetalum ferrugineum (fig. 119), from Adelaide, the first few leaves are spathulate and more or less lobed, the final ones linear. Again, in Dodonæa viscosa, also from Adelaide, the first leaves are lobed, the subsequent ones simple. Heterospermum is another interesting case.

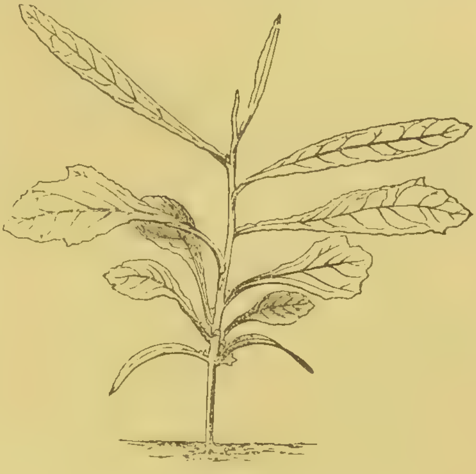

Fig. 119.—Seedling of *Lasiopetalum ferrugineum.* Half nat. size.

Relation of the Seedling to the Seed.

To return for a moment to the case of seedlings. The question of course arises whether the embryo conforms to the seed, or whether the shape of the seed is determined with reference to the form of the cotyledons. The seeds, however, are evidently constructed with reference to the habits, conditions, &c. of the plant. I have elsewhere dealt with the structure of the seed, and must content myself here with the simple statement that we have no reason to suppose that it is influenced by the form of the embryo. On the other hand, it seems equally clear that the form of the embryo, and especially of the cotyledons, is essentially influenced by that of the seed.

The Tea (*Thea*), for instance, presents us with a very interesting case, in which the cotyledons vary greatly in shape, following that of the seed, and depending on the number of ovules which develop; they are contained in a wooden capsule, and are variously compressed. In Citrus also the cotyledons are unequal and irregular, several embryos being contained in each seed, and sometimes squeezed together in the utmost confusion.

In several other cases among those which have been already referred to, we can hardly doubt, I think, that the form of the cotyledon has been affected by the seed and not *vice versa*.

Let me in conclusion take one other illustration. The cotyledons of the Sycamore (fig. 9) are long, narrow, and strap-like; those of the Beech (fig. 13) are short, very broad, and fan-like. Both species are exalbuminous, the embryo occupying the whole interior of the seed.

Now in the Sycamore the seed is more or less an oblate spheroid, and the long ribbon-like cotyledons, being rolled up into a ball, fit it closely, the inner cotyledon being often somewhat shorter than the other. On the other hand, the nuts of the Beech are more or less triangular: an arrangement like that of the Sycamore would therefore be utterly unsuitable, as it would necessarily leave great gaps. The cotyledons, however, are folded up like a fan, but with more complication, and in such a manner that they fit beautifully into the triangular nut.

Can we, however, carry the argument one stage further? Why should the seed of the Sycamore be globular, and that of the Beech triangular? Is it clear that the cotyledons are constituted so as to suit the seed? May it not be that it is the seed which is adapted to the cotyledons? In answer to this we must examine the fruit, and we shall find that in both cases the cavity of the fruit is approximately spherical. That of the Sycamore, however, is comparatively small, say $\frac{1}{5}$ inch in diameter, and contains one seed, which exactly conforms to the cavity in which it lies. In the Beech, on the contrary, the involucre is at least twice the diameter, and contains from two to four fruits, which consequently, in order to occupy the space, are compelled (to give a familiar illustration, like the segments of an orange) to take a more or less triangular form.

Thus, then, in these cases, starting with the form of the fruit, we see that it governs that of the seed, and that of the seed again determines that of the cotyledons. But though the cotyledons often follow the form of the seed, this is not invariably the case: other factors must also be taken into consideration; but when this is done, we can, I venture to think, throw much light on the varied forms which seedlings assume.

RANUNCULACEÆ.

Bentham et Hooker, *Genera Plantarum*, i. 1.

Fruit and Seed.—The fruits of Ranunculaceæ are either achenes often more or less pointed, sometimes feathery (Clematis, some species of Anemone), or follicles, sometimes united into a capsule (Nigella), or one- to few-seeded berries (Actæa).

The seeds are erect, pendulous, or horizontal;[1] the embryo is minute except in Trautvetteria.

The shape of the seed varies with that of the carpels and the number of ovules. There are four principal types: rounded and smooth, granular, angular, and winged.

When the fruit is an achene (Ranunculus, Clematis, Anemone) the shape of the seed conforms to the interior of the achene.

In Thalictrum the achenes are ribbed, in Ranunculus they are wrinkled (water forms), or smooth, in some slightly hairy, in others (R. arvensis, R. parviflorus) covered with tubercles, or spines which are often more or less hooked, and probably serve to promote the dispersion of the seeds. In some (R. scapigerus, R. multiscapus, &c.) the style itself is hooked. In other cases dispersion is aided by the presence of wings, or by a long feathery process consisting of the persistent style. This also serves a useful purpose by fixing the seed to the ground and thus enabling the seedling to emerge from the testa; as, for instance, in Clematis graveolens.

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[1] The ovules are anatropous, either solitary, erect, and with a ventral raphe (Ranunculeæ), or pendulous with a dorsal raphe (Clematideæ, Anemoneæ). The result of this is that in both the pollen-tube has direct access to the micropyle, which would not otherwise be the case.

In Clematis fœtida the hairs are very long, but are confined to the lower part of the style; while in others, as for instance in C. Viticella, the style is quite short.

So also in Anemone, some species, as for instance A. virginiana, have the achenes hairy, terminating in a short, more or less curved, horn; while in others the achene bears a long feathery tail.

In the Helleboreæ the fruit is follicular, with numerous horizontal ovules; and the seeds are winged (Nigella orientalis), rounded (some species of Nigella), smooth (Aquilegia), or angular (some Delphiniums). This latter difference is perhaps due to the fact that in Aquilegia many of the ovules become aborted, so that the seeds have plenty of room to expand, while in Delphinium they are generally crowded together.

In Aquilegia the plants, when agitated by the wind, scatter the seeds in all directions, and their smoothness under these circumstances perhaps facilitates their dispersal.

Nigella orientalis differs from most of its congeners in the possession of winged seeds. The testa is loose and reticulated.

Actæa has baccate fruits, with numerous angled seeds. The testa is very thick.

Cotyledons.—The prevalent type of the cotyledons is broad, and bluntly ovate. They are typically three- to five-veined, though the variation is not easily seen in fresh specimens. They are larger, as a general rule, in the annual than in the perennial species. In some of the marsh species they are narrow and somewhat elongated, as is also the case with the leaves.

The cotyledons generally have a petiole, but sometimes they are sessile, as for instance in Delphinium Staphysagria (fig. 135). This, as I have suggested in my introductory chapter, is perhaps because, while those of Delphinium elatum, for instance (fig. 136), are attached close to the ground, those of D. Staphysagria are carried up by the hypocotyl, and do not therefore require stalks of their own.

The greatest amount of modification occurring in any one genus is perhaps found in Anemone. In A. nemorosa the cotyledons are connate by their edges, forming a tube obliquely split at the top. The petioles of the cotyledons are more or less connate in most species at the base; they are united for half their length in A. Coronaria, nearly to the top in A. rupicola, and quite so in A. polyantha. In Anemone nemorosa the petioles are completely suppressed.

Connate petioles also occur in Trollius, Delphinium nudicaule (fig. 137), D. trollifolium, and in some other species to the same extent as in Anemone polyantha.

In Clematis recta the cotyledons are fleshy and do not leave the seed. As usual in such cases the first few leaves are reduced to scales.

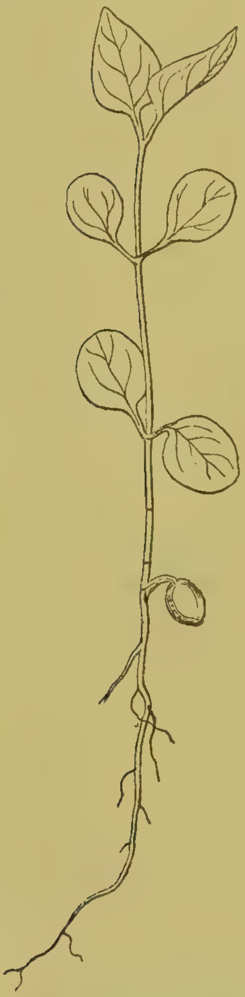

Fig. 120.—*Clematis recta*, var. *lathyrifolia*. Nat. size.

Clematis recta, L., *var.* lathyrifolia (fig. 120).

Primary root yellowish, with short lateral rootlets.

Hypocotyl short and tapering into the primary root.

Cotyledons petiolate, subterranean, and not leaving the seed.

Stem erect, terete, but becoming angular above, glabrous; 1st internode (in sketched specimen) short and hidden by remains or sheaths of cotyledons; 2nd 2 mm. long; 3rd 6 mm.; 4th 7 mm.; 5th 18 mm.; 6th 11·5 mm.

Leaves compound in the adult plant, simple in seedling stage, cauline, opposite, exstipulate, petiolate, glabrous, green above, subglaucous beneath.

The leaves of Nos. 1–3 pair inclusive had fallen off; as above mentioned they are, as usual in such cases, quite small.

No. 4 pair, rotund-ovate, obtuse, entire.

No. 5 pair, rotund, obtuse, entire, sub-trinerved.

No. 6 pair, ovate, acute, entire, trinerved at the base.

Ultimate leaves (in this variety) bipinnate, leaflets lanceolate, entire, acute, three- or five-nerved; terminal one larger, trifid, or tripartite, or divided to the rachis.

Clematis recta, *L.*

Fruit an achene very shortly stipitate, broadly oval, much compressed laterally, deep brown, nearly or quite glabrous, terminated by a long, feathery, persistent style; walls of achene very much thickened at the sutures by a mass of cortex on each side, making in all four pieces; considerably thinner at the sides.

Seed suborbicular and conforming to the interior of the achene, with rounded or obtuse edges; outer seed-coat (testa) thicker, deep brown; inner (tegmen) very thin, membranous, pale brown; hilum and micropyle at the upper, basal end of the seed; funicle short.

Endosperm copious, fleshy, white.

Embryo minute, straight, colourless, lying in the endosperm, close to its upper end and towards the dorsal edge of the seed.

Cotyledons sessile, obtuse, entire, plano-convex, lying closely applied face to face in the narrow plane of the seed; radicle very short, and blunt, shorter than the cotyledons, close to the upper end of the endosperm.

Clematis graveolens, *Lindl., var.* orientalis (fig. 121).

Achene narrowly ellipsoid, laterally compressed, densely covered with silky ascending hairs, and ending in a long, feathery style; pericarp comparatively thin.

Seed conforming to the interior of the achene, suspended from near the apex of the cell, anatropous; seed-coats thin.

Endosperm as in C. recta.

Embryo differs from that of C. recta in being larger, and in the ovate, or suboval cotyledons lying in the *broader* plane of the seed, *i.e.* with their backs to the sides of the seed and their edges to the sutures; radicle oblong, obtuse, stout, about equal in length to the cotyledons, but less in diameter than their breadth.

The radicle in germination pushes out at the apex of the achene, which splits rather deeply into two valves, thus allowing the embryo free exit. The primary root develops numerous root-hairs at an early stage, which fix the seedling firmly in the soil.

The achene is rarely if ever carried up by the cotyledons, but is securely fixed in the soil by the long, feathery, persistent style.

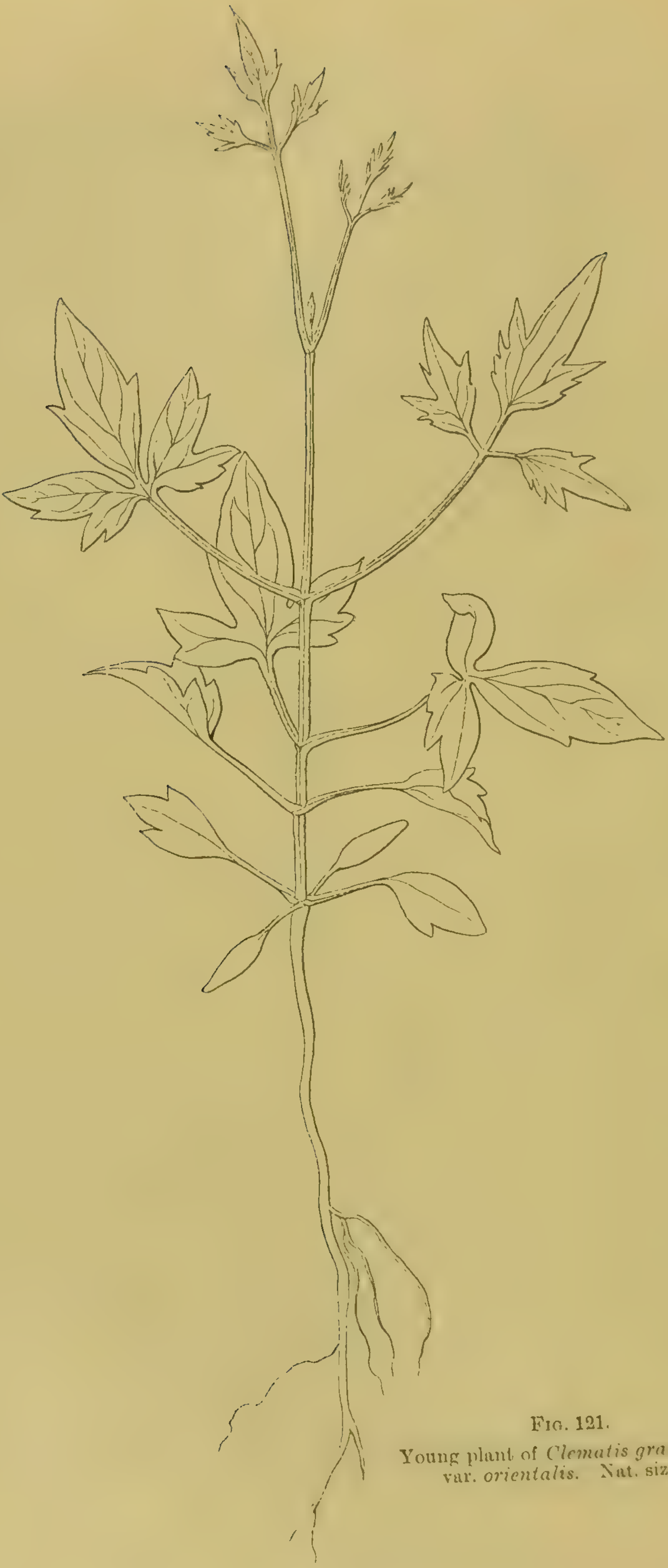

FIG. 121.

Young plant of *Clematis graveolens*, var. *orientalis*. Nat. size.

The cotyledons (fig. 121) are lanceolate, obtuse, narrowed at the base into a short petiole, obscurely trinerved, glabrous, pale greenish-yellow, but not yet properly coloured, or full-sized. Hypocotyl rather long, slender, almost colourless or tinged with purple at the apex, glabrous.

Atragene alpina, *L.* (fig. 122).

Hypocotyl terete, pale green, emerging 4 mm. above the soil.

Cotyledons slightly pubescent, dark green, petiolate; lamina ovate, obtuse, 8 mm. long, 6 mm. broad; petiole flattened above, 6 mm. long.

Stem undeveloped in seedling stage.

Leaves of seedling simple, radical (ultimately cauline), apparently alternate or the pairs very unequally developed, subdistichous, exstipulate, pubescent, deep green, petiolate, petioles channelled above, dilated and clasping at the base, pubescent.

No. 1. Small, transversely oblong or oval.

No. 2. Broader than long.

No. 3. Transversely oval, obscurely tridentate.

No. 4. Trilobed with obtuse or emarginate lobes.

No. 5. Trifid; middle lobe broadly obovate, emarginate, lateral lobes bidentate.

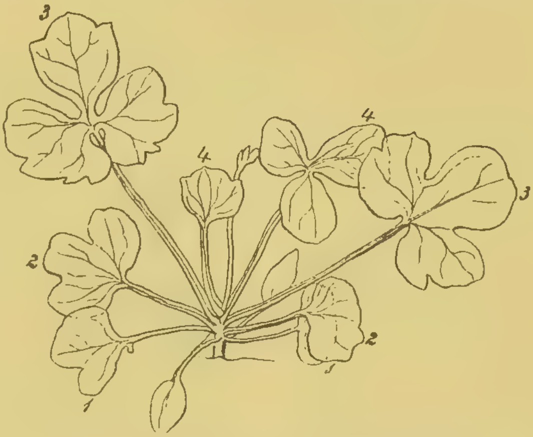

FIG. 122.—*Atragene alpina*, var. *genuina*. Nat. size. The numbers indicate the order of development of the leaves.

No. 6. Tripartite; middle lobe rotund-cuneate, tridentate; lateral lobes transversely broadest, unequally dentate along the apex.

No. 7. Tripartite; lobes broadly obovate, emarginate.

No. 8. Subreniform, shortly trifid.

Anemone rivularis, *Buchan.* (fig. 123).

Primary root stout, tapering downwards, dark-coloured or brown with lateral rootlets of same colour.

Hypocotyl short, stout, white or suffused with red, 3–4 mm. long.

Cotyledons foliaceous, glabrous, petiolate; petiole semiterete, channelled above, dilated and connate at the base, bright reddish purple, 12 mm. long; lamina oval, obtuse, mucronate, obscurely trinerved, 1 cm. long, 6 mm. broad.

Stem herbaceous.

Leaves radical (ultimately cauline), simple, alternate, exstipulate, petiolate, hairy all over; petioles semiterete, channelled above, dilated towards the base.

No. 1. Reniform, deeply tripartite, five-nerved; middle segment cuneate, three- to five-toothed above; teeth triangular, mucronate, frequently aristate; lateral segments bifid and toothed above; teeth similar to those of the middle segment.

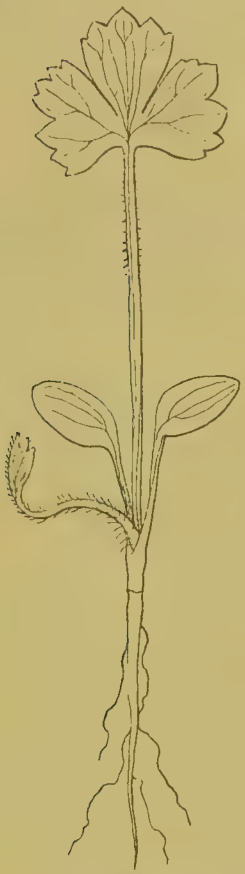
Fig. 123.—*Anemone rivularis.* Nat. size.

Anemone fulgens, *Gay.*

Primary root slender, flexuous, brown, densely covered with root-hairs.

Hypocotyl subterranean, shortly fusiform, deep brown and covered with longitudinal corky ridges, 3–5 mm. long, fleshy or tuberous.

Cotyledons roundly ovate, oblique, varying greatly in shape and size, smaller, but otherwise very similar to those of A. rivularis.

Stem subsequently forming an underground fleshy rhizome, and not developed in the seedling.

Leaves simple, radical, alternate, exstipulate, petiolate, with the petiole sheathing at the base, ultimately much divided.

Nos. 1–2. Leaf small, reniform, three- to five-nerved, with three to five cuspidate teeth; finely ciliate.

Anemone Coronaria, *L.*[1]

Hypocotyl suppressed or very short and subterranean.

Cotyledons with petioles connate for two-thirds of their length, and appearing to spring from one side; free part of petioles terete, channelled on the upper side; limb oval or oblong, emarginate, glabrous, 5 mm. long, 3·5 mm. broad.

Stem a subterranean fleshy rhizome, perennial.

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[1] Irmisch, *Bot. Zeit.* 1856, taf. i.

Leaves radical, ternately cut, alternate, exstipulate, petiolate; petioles subterete, channelled above, sheathing at the base.

No. 1. Tri-fid or -partite, glabrous, springing from the bud, which is situated some distance beneath the soil, deep green above, red or purple beneath; middle lobe trifid, cuneate at the base, and the middle segment often tridentate; lateral lobes unilateral and bifid or toothed along the posterior side.

Anemone polyantha, *Don.*

Cotyledons connate by their petioles to the very top, and the laminæ also sometimes connate at the base, appearing perfoliate.

Leaves. No. 1. Reniform, trifid, trinerved, terminal lobe tridentate; lateral lobes bidentate. The plumule emerges at the base of the cotyledon.

Ultimate leaves orbicular, five- to nine-lobed and -nerved; lobes obtuse, frequently trifid, cut, toothed—basal ones much overlapping.

Anemone rupicola, *Camb.*

Cotyledons connate by their petioles nearly to the top.

Leaves. No. 1. Cuneate, trinerved, shortly trifid; middle lobe tridentate; lateral lobes bi- to tri-dentate. This leaf is sometimes absent.

No. 2. Reniform-triangular, deeply trifid, three- to five-nerved; middle lobe cuneate, tridentate; lateral lobes bifid or sub-bifid and slightly toothed.

Anemone nemorosa, A. Pulsatilla, and A. Hepatica have been described and figured by Irmisch.[1]

Thalictrum minus, *L.* (fig. 124).

Hypocotyl terete, glabrous, succulent, reddish, 2–4 mm. long.

Cotyledons broadly ovate, obtuse, subcordate at the base, deep glaucous green, petiolate; petiole 3–5 mm. long, glaucous purple, subterete, flattened above, glabrous; lamina 4–6 mm. long, 3–4·5 mm. broad.

Stem leafy.

Leaves compound, alternate, exstipulate, petiolate, radical (and cauline ultimately) deep green, minutely pubescent; petioles terete, dilated and sheathing at the base, minutely pubescent.

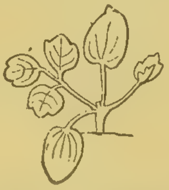

Fig. 124.—*Thalictrum minus.* Nat. size.

No. 1. Ternate, leaflets rotund, trifid, reticulate—the lateral ones being oblique on the posterior side.

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[1] *Bot. Zeit.* 1856, pp. 1, 17.

Ranunculus Cymbalaria, *Pursh.* (fig. 125).

Primary root elongated, slender, furnished with a dense tuft of hairs at the base, and scattered ones, gradually becoming shorter towards the apex.

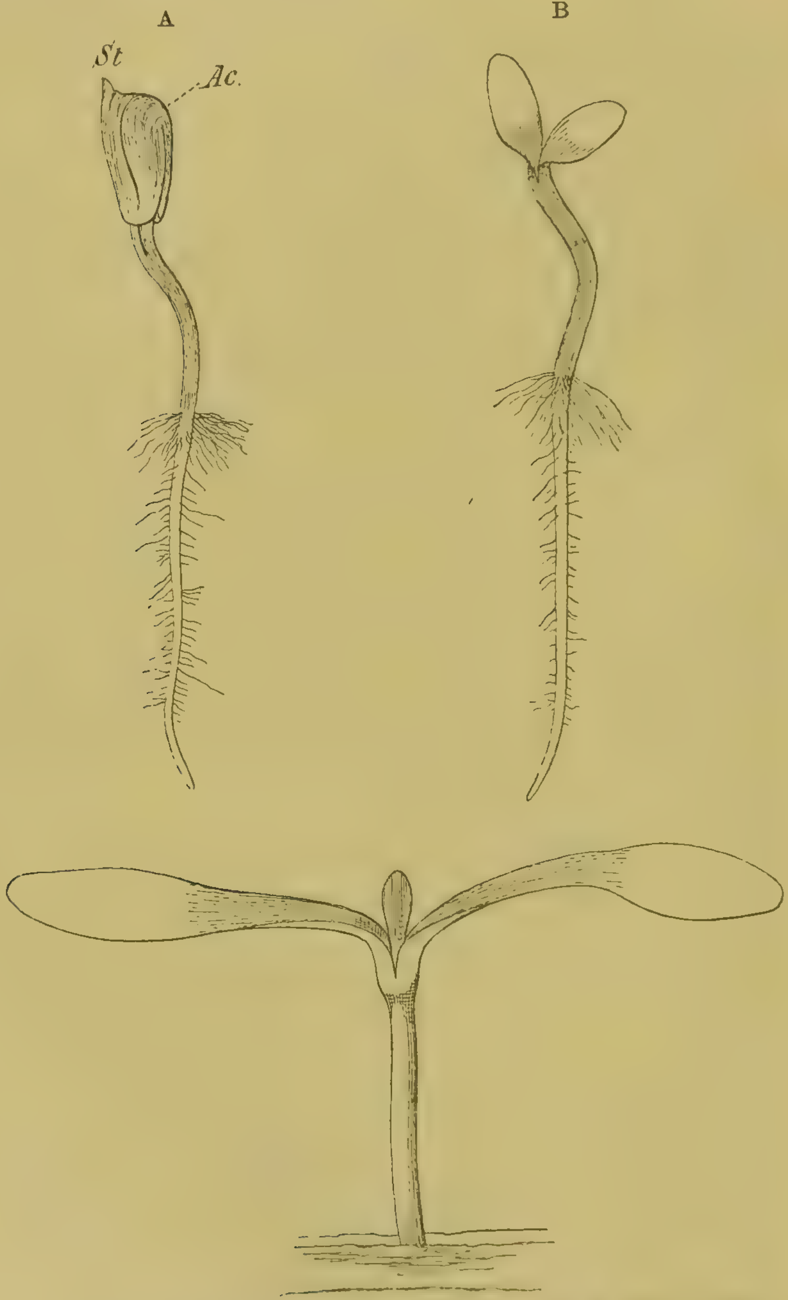

Fig. 125.—*Ranunculus Cymbalaria*, × 8. A, seedling, with the cotyledons still in the achene, *Ac*; *St*, stigma. B, seedling three days old. C, seedling thirty-nine days old.

Hypocotyl glabrous. Petioles of cotyledons just visible, but the cotyledons have not yet escaped from the achene.

Three days after germination: Cotyledons now free, oblong, obtuse, entire, shortly petiolate.

Thirty-nine days after germination: Cotyledons spathulate, entire, petiolate, glabrous, pale green, 3·5–5 mm. long, including the petioles, which are connate at the base. Plumule developing and first leaf appearing.

Sixty days after germination: The cotyledons have longer petioles than at the last stage, but are otherwise similar. Two first leaves oval, obtuse, entire, glabrous, with long petioles dilated and sheathing at the base.

Ranunculus acris, *L.* (fig. 126).

Primary root a tap-root with numerous colourless lateral rootlets.

Hypocotyl short, ·5 mm. long, 1 mm. thick, cylindrical, colourless near the base, greyish-brown near the cotyledons, where it also develops root-hairs.

Cotyledons petiolate, the petioles connate and sheathing at the base; lamina about 1 cm. long, nearly ·5 cm. broad, ovate-lanceolate, obtuse, entire, with sunk midrib, glabrous, light green; petiole as long as lamina, nearly 1 mm. broad, slightly channelled and glabrous.

Leaves simple, radical and cauline, alternate, exstipulate, palmati-nerved and -lobed, slightly pubescent on both surfaces, deep green above, paler beneath; petiolate, petiole semiterete, channelled above, sheathing at the base.

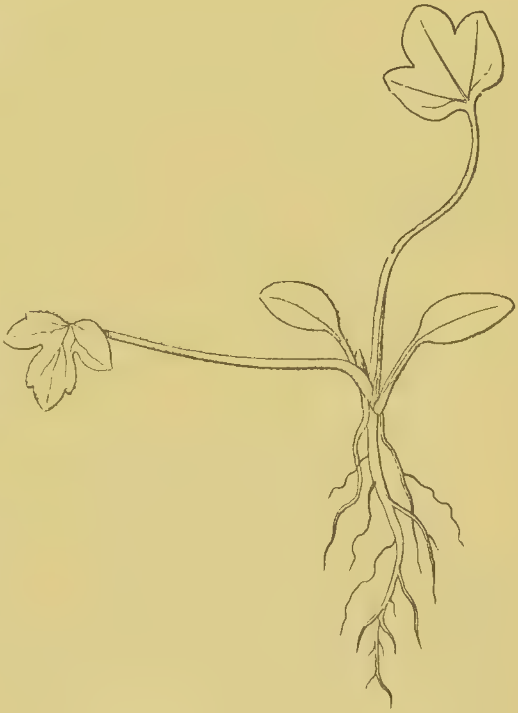

Fig. 126.—*Ranunculus acris.* Nat. size.

No. 1. Subrotund from a flattened base, five-nerved, trifid, lobes obtuse.

No. 2. Trilobed, lobes ovate, obtuse, often showing a small tooth on each side.

R. millefoliatus, which has been described and figured by Irmisch,[1] belongs to this type.

Ranunculus arvensis, *L.*[2] (fig. 127).

Primary root tapering downwards, rather stout, with very few lateral rootlets ; a number of adventitious roots spring from the base of the hypocotyl and are soon equal to, or stronger than, the primary one ; adventitious roots are also given off from the cotyledonary node.

Hypocotyl stout, succulent, colourless, 7 mm. to 1·7 cm. long, glabrous.

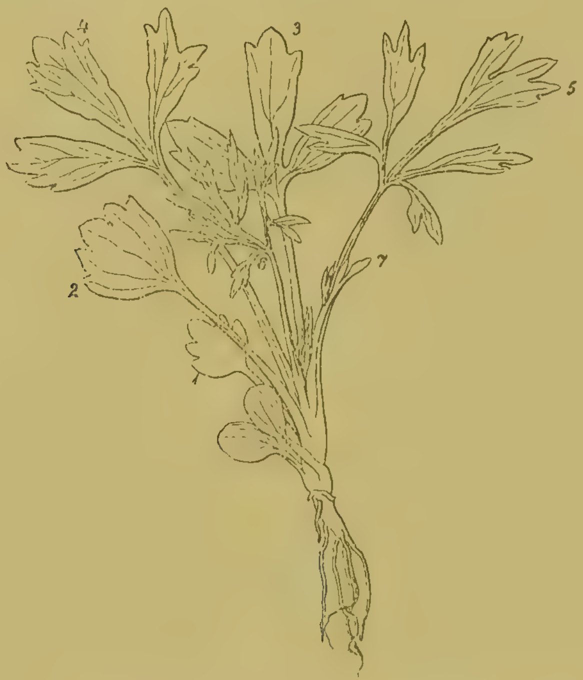

Fig. 127.—*Ranunculus arvensis.* Half nat. size.

Cotyledons opposite, glabrous, pale green ; petioles channelled above, convex beneath, much dilated at the base, and connate ; lamina oblong, oval, 12 mm. long, 8 mm. broad.

Stem erect, terete, glabrous, pale green, annual ; 1st–4th internode undeveloped, 5th more or less lengthened and sheathed by the bases of the petioles.

Leaves simple, radical and cauline, alternate, exstipulate, ciliate, light green, ultimately glabrous, petiolate ; petioles semiterete, channelled above, slightly pubescent when young, much dilated and sheathing at the base, with somewhat ciliate sheaths.

No. 1. Rotund-cuneate, five-toothed.

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[1] *Bot. Zeit.* 1865.

[2] Irmisch, *Bot. Zeit.* 1857, taf. ii.

No. 2. Broadly obovate-cuneate, obscurely five-nerved with five large teeth above.

No. 3. Tripartite; divisions cuneate, tridentate above, basal ones not opposite.

No. 4. Tripartite, with the basal divisions nearly opposite, teeth more numerous above.

No. 5. Trisected; middle segment acutely cuneate, unequally trifid, lobes slightly toothed at the apex; lateral segments bipartite with their anterior lobes trifid, narrowly cuneate, and their posterior lobes bifid above.

No. 6. Trisected; middle segment tripartite, divisions linear, entire or slightly toothed; lateral segments bipartite, divisions divaricate, more or less cut up into linear pieces.

Ranunculus hederaceus (fig. 128).

Primary root as in R. acris, but few lateral rootlets.

Hypocotyl suppressed.

Cotyledons opposite, nearly equal; base of petioles sheathing, petioles about 10 mm. long, ·75 mm. broad, blade 7·5 mm. long and nearly as broad, suborbicular, rounded at both ends, slightly emarginate, distinctly penninerved, reticulate, glabrous, membranous, bright green.

Leaves radical and cauline, alternate, exstipulate, petiolate.

No. 1. Petiole glabrous, channelled, sheathing at base, 20 mm. long, 1 mm. broad; lamina broadly cordate, trifid, palmatinerved, reticulate, glabrous, bright green, 10–15 mm. long, and as broad.

No. 2. Similar but five-fid.

NOTE.—The cotyledons of R. tuberosus, R. caucasicus, R. Flammula, R. Boræanus, R. macrophyllus, R. Brutius, R. Stevensi, R. cortusæfolius, and possibly many others, have their cotyledons slightly emarginate when fully developed.

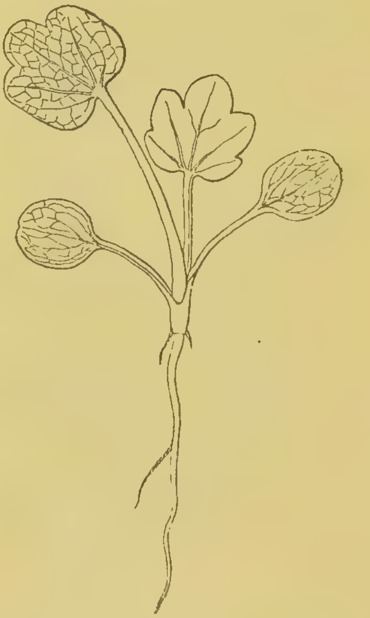

FIG. 128.
Ranunculus hederaceus. Nat. size.

Ranunculus repens, *L.* (fig. 129).

Hypocotyl erect, terete, short, mostly subterranean, colourless, glabrous.

Cotyledons rotund-ovate, obtuse, entire, deep green, opaque, glabrous, obscurely three- to five-nerved from the base; lamina 5–6 mm. long, 4·5–5 mm. broad; petiole semiterete, slightly channelled above, slightly dilated at the base, 6–7 mm. long.

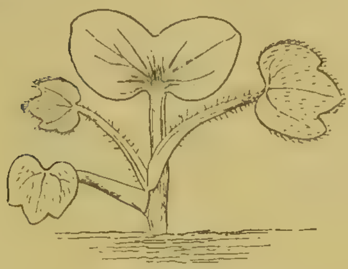

Fig. 129.
Ranunculus repens, × 2.
Abnormal specimen.

In the accompanying sketch is a seedling with the petioles and basal part of lamina united along one edge so as to appear like one large bifid cotyledon.

Stem. Several of the first internodes undeveloped.

Ceratocephalus falcatus, *Pers.* (fig. 130).

Primary root suddenly breaking up into a number of equally strong rootlets.

Hypocotyl fleshy, terete, tapering into the root, reddish beneath the cotyledons.

Cotyledons linear, obtuse, with revolute margin, fleshy, deep green above, paler beneath, 1 cm. long, 2 mm. broad.

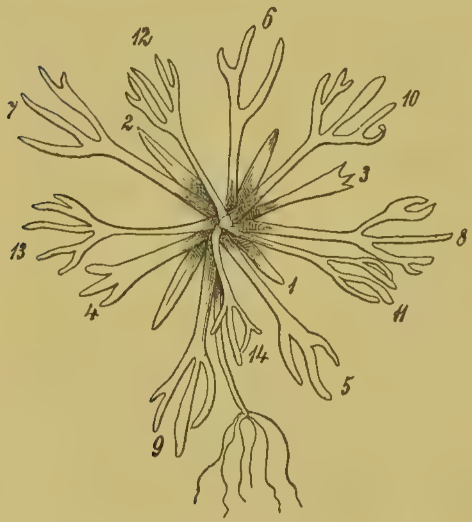

Fig. 130.
Ceratocephalus falcatus. Nat. size.

Stem annual, very short; internodes undeveloped.

Leaves simple, radical in a rosette, alternate, exstipulate, rather succulent, bright green above, paler beneath, woolly when young, glabrescent, petiolate; petioles flattened on both surfaces, dilated at the base.

Nos. 1 and 2. Linear, entire, similar to the cotyledons.

No. 3. Spathulate; apex tridentate.

No. 4. Spathulate, trifid.

Nos. 5 and 6. Cuneate, unequally trilobed.

Nos. 7 and 8. Cuneate, tripartite; segments linear, lateral ones bifid at apex.

No. 9. Tripartite, with linear segments.

No. 10. Tripartite; lateral segments unequally lobed.

No. 11. Doubly bipartite.

No. 12. Tripartite; lateral segments bifid.

No. 13. Similar.

No. 14. Cuneate, tripartite; lateral segments unequal.

Trollius Ledebouri, *Rchb., var.* polycephalus, *Rgl.* (fig. 131).

Primary root slender, normal, soon superseded by strong adventitious roots from the base of the leaves and cotyledons.

Hypocotyl not developed.

Cotyledons ovate, obtuse, entire, alternately penninerved; nerves indistinct and seen only by transmitted light, glabrous, bright green above, much paler beneath, petiolate; petioles semiterete, channelled above, connate for about one-third of their length, much dilated and sheathing at the base, split on one side to allow the egress of the plumule, light shining green, glabrous, 8–11 mm. long; lamina, 6·5–8 mm. long, 5–5·5 mm. broad.

Stem herbaceous, forming a perennial rhizome which sends up annual flowering stems; primary internodes undeveloped.

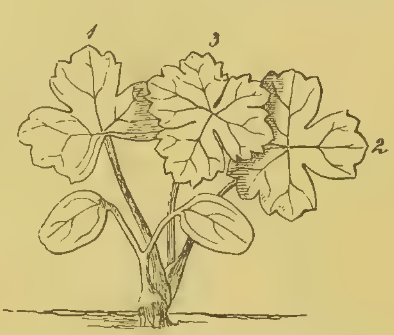

FIG. 131.—*Trollius Ledebouri*, v. *polycephalus*. Nat. size.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, palmati-nerved, and -lobed, reticulate; reticulations best seen in young leaves; light green above, paler or almost glaucous beneath, shining on both surfaces; petioles terete in the seedling, tapering upwards, light green, often tinged with red below, much dilated and clasping at the base.

No. 1. Rotund-cordate, palmately five-nerved, and three-lobed or five-lobulate; middle lobe cuneate, slightly trifid, with obtuse glandular cuspidate teeth; lateral lobes bifid and slightly toothed with glandular, cuspidate teeth.

No. 2. Similar.

No. 3. Tripartite; middle lobe broadly cuneate with numerous glandular cuspidate teeth; lateral lobes broader at the base than the middle lobe, slightly bifid with similar teeth.

Nigella sativa, *L.* (fig. 132).

Primary root slender, tapering, flexuose.

Hypocotyl erect, terete, glabrous, pale green, 13 mm. long, 1 mm. thick.

Cotyledons petiolate, glabrous; lamina oblong, obtuse, tapering into the petiole, 13 mm. long, 6 mm. broad; petiole channelled above, 8·5 mm.

Stem annual, erect, terete, pubescent, pale green; 1st internode undeveloped; 2nd and 3rd 3 mm. long; 4th 1 mm. long.

Leaves simple, cauline, alternate, exstipulate, bright green and shining on both sides, sparsely pubescent, petiolate; petioles channelled above, slightly ridged beneath, dilated and sheathing at the base, pale green, pubescent.

No. 1. Cuneate, deeply trifid with oblong, obtuse segments.

No. 2. Cuneate, tripartite, divisions bifid.

No. 3. Tri-pinnatisect; basal lobes 1–2-pinnatifid; terminal lobe tripartite.

No. 4. Similar to the last but rather more cut up.

The cotyledons of N. integrifolia closely resemble those of N. sativa; as also do those of N. damascena, which, however, are somewhat broader in the middle.

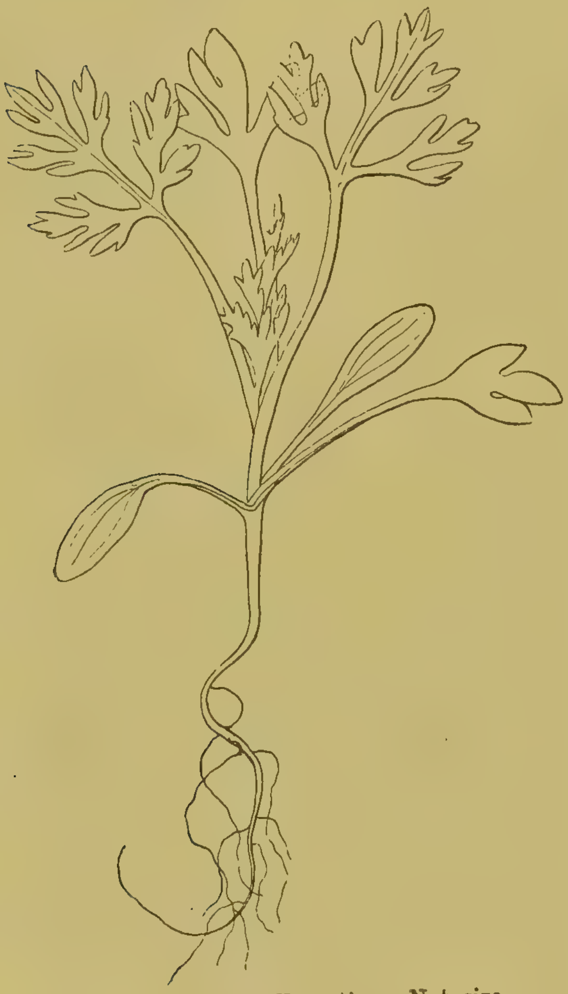

Fig. 132.—*Nigella sativa.* Nat. size.

Aquilegia chrysantha, *Gray, var.* truncata (fig. 133).

Hypocotyl 3–7 mm. long, 1 mm. thick, glabrous, purple.

Cotyledons petiolate; petioles terete or flattened above, connate at the base, 7 mm. long, purple, glabrous; lamina ovate, obtuse, entire, glabrous, faintly trinerved, glaucous blue or often tinged with purple, 7 mm. long, 5 mm. broad.

Leaves radical, alternate, ternately compound, glabrous, petiolate;

petiole dilated and sheathing at the base, stipuliform as in the Umbelliferæ.

No. 1. Lamina ternate; leaflets trifid or the lateral ones bifid, petiolulate; lobes obtuse, rounded; petiolules 1 mm. long, the middle one longer; petiole terete, 8–15 mm. long, purplish.

The seedlings of Aquilegia flavescens closely resemble those of A. chrysantha, and the same may be said of A. cærulea.

The cotyledons of Aquilegia atropurpurea, A. Wittmanniana, A. dichroa, and probably others, have a slight emargination when fully developed.

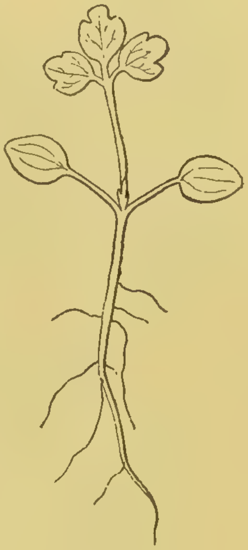

FIG. 133.—*Aquilegia chrysantha*, var. *truncata*. Nat. size.

Isopyrum grandiflorum, *Fisch.*

Primary root slender, tapering, with lateral rootlets.

Hypocotyl short, glabrous, tapering indistinguishably into the root, and mostly subterranean.

Cotyledons small, glaucous, glabrous, petiolate, orbicular or rotund-ovate; lamina 3 mm. long, 2·5 mm. broad; petiole slender, 5 mm. long.

Stem herbaceous or shrubby, with very short scarcely developed internodes, densely covered with the withered petioles of old leaves.

Leaves biternate on the adult plant (primary ones simply ternate), radical and ultimately cauline, alternate, exstipulate, glabrous, glaucous, purplish beneath, petiolate; petioles slender, terete, or slightly flattened above, dilated and sheathing at the base, glaucous, glabrous.

Nos. 1–3. Ternate; leaflets suborbicular, entire.

No. 4. Ternate; terminal leaflet unequally bifid; lateral leaflets bifid or bipartite.

No. 5. Ternate; terminal leaflet trifid; lateral leaflets unequally bifid, with the smaller lobe on the posterior side.

No. 6. Ternate; terminal leaflet tripartite with sub-obovate segments; lateral leaflets bipartite with the posterior segment oval, the much larger anterior one rotund-obovate.

No. 7. Ternate; terminal leaflet tripartite, with the middle segment obovate, the lateral ones narrower; lateral leaflets bipartite with the posterior segments small and oval, the anterior one elliptic, obtuse.

No. 8. Almost biternate, with obovate leaflets.

Ultimate leaves biternate with the secondary segments tripartite, varying greatly in size from ½–2 inches in diameter; primary divisions triangular; secondary cuneate; ultimate segments obovate or cuneate, entire.

In Isopyrum fumarioides the cotyledons are somewhat more elongated.

Delphinium Staphysagria, *L.* (fig. 134).

Fruit of one to five follicles, each containing many seeds and dehiscing along the ventral suture.

Seeds obovoid, rather acutely trigonous, or variously ridged and angled; testa thick and corky, deeply reticulated, black externally; tegmen thin and membranous, pale brown; chalaza apical and as well as the raphe rather obscure; micropyle and hilum basal.

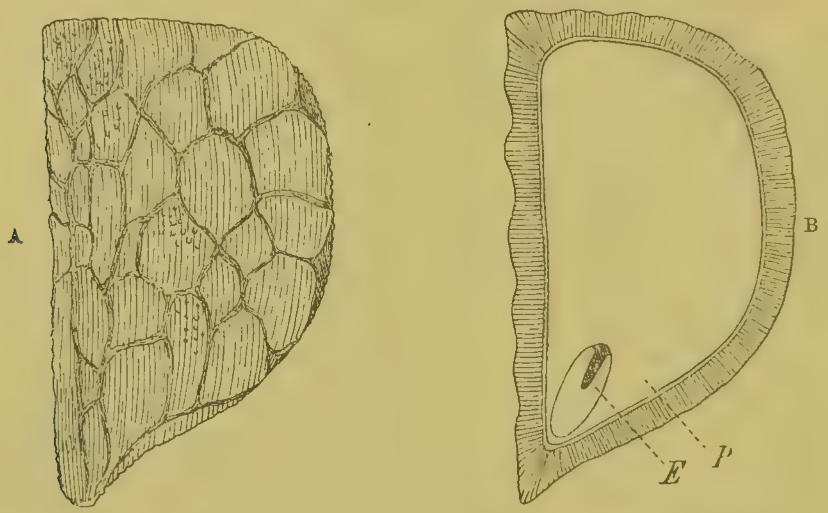

Fig. 134.—*Delphinium Staphysagria.* A, seed × 13. B, longitudinal section of seed: *E*, embryo; *P*, endosperm.

Endosperm copious in the mature seed, white with a small subtransparent mass separating the cotyledons.

Embryo straight, minute, embedded in the endosperm at the base of the seed; cotyledons ovate, obtuse, entire, sessile, diverging; radicle short, obtuse.

Seedling (fig. 135).

Primary root tapering downwards with numerous fleshy lateral rootlets, dark-coloured.

Hypocotyl erect, terete, succulent, glabrous, colourless below ground, pale green above, 3 cm. long, 3 mm. thick.

Cotyledons ovate-oblong, obtuse, glabrous, fleshy; upper surface deep green, with three milk-white veins, shortly petiolate; petiole 3 mm. long; lamina 13·5 mm. long, 7·5 mm. broad.

Stem herbaceous, biennial, elongated before flowering.

Leaves simple, radical, ultimately cauline, alternate, exstipulate, petiolate; both petiole and lamina pubescent when young, ultimately becoming glabrous, deep green and shining above, with anastomosing milk-white veins, paler green and shining beneath; petioles channelled above, dilated and sheathing at the base, rather thick.

No. 1. Palmately tri-nerved and -fid: middle lobe minutely tridentate; lateral lobes bidentate; teeth triangular, tipped with a mucro.

No. 2. Palmately five-nerved and three-lobed; middle lobe unequally tridentate; lateral lobes unequally bifid.

No. 3. Palmately five-nerved and five-lobed; terminal and middle lobes unequally tridentate; basal lobes unequally bifid.

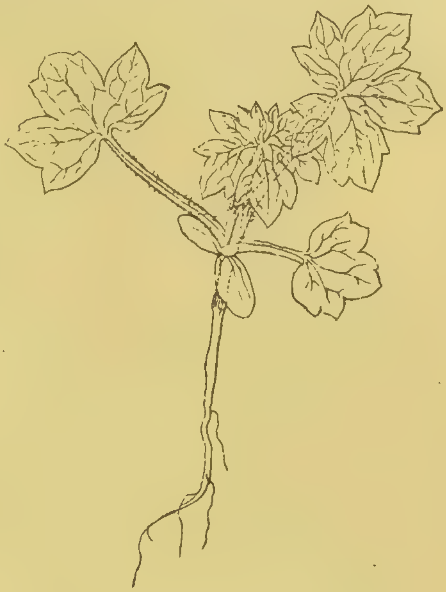
FIG. 135.—*Delphinium Staphysagria*
Half nat. size.

No. 4. Palmatipartite; nerves and divisions five; terminal and middle lobes unequally trifid (middle much the largest), subrhomboid; lateral or basal lobes overlapping, dentate or sublobulate along the posterior or basal side.

Ultimate leaves palmately five- to seven-nerved and -lobed, or -partite, reticulated with white or green nerves; one to three of the terminal or central lobes subcuneate and trifid; the two to four basal lobes unequally bifid with the smaller lobe on the posterior or basal side. Uppermost leaves tripartite, trifid, or entire.

Delphinium elatum, *L.*

Seed obovoid, triangular or variously compressed, pale or deep brown; testa membranous, shrivelled or wrinkled; tegmen paler and thinner; hilum &c. as in D. Staphysagria.

Endosperm as in D. Staphysagria, copious, fleshy, white, except a small quantity between the cotyledons and at their apex, which is transparent.

Embryo larger than in D. Staphysagria, while the cotyledons have short petioles; otherwise similar.

Seedling (fig. 136).

Primary root perennial, fleshy, with a few rootlets, which are fleshy near its base and fibrous towards its apex.

Hypocotyl merging with and scarcely distinguishable from the root, stout, fleshy,

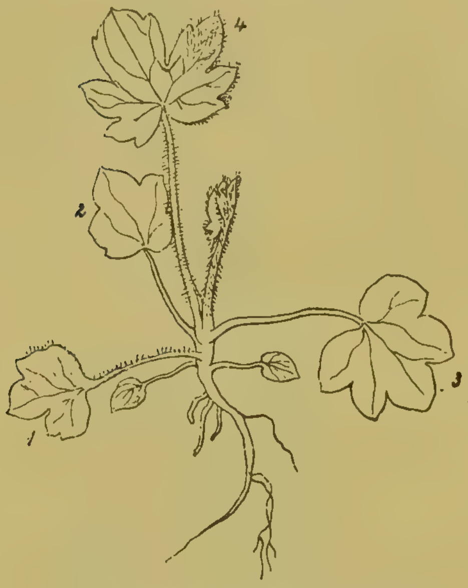

FIG. 136.—*Delphinium elatum*, var. Two-thirds nat. size.

Cotyledons oval, foliaceous, often unequal in size, slightly pubescent, petiolate; petiole subterete, flattened above, about 1 cm. to 1·5 cm. long; lamina ovate, subacute, 8 mm. long, 6 mm. broad.

Stem undeveloped in seedling stage.

Leaves simple, radical and cauline, alternate, exstipulate, coarsely hairy on both surfaces, almost villous on the under surface and the petioles; petiole dilated and sheathing at the base, subterete, channelled above.

No. 1. Palmately trifid, trinerved, lobes frequently unequal.

No. 2. Similar but larger and foreshadowing further subdivision on the posterior or basal side.

No. 3. Palmately five-fid, five-nerved, with rounded, obtuse lobes.

No. 4. Palmately tripartite, five-nerved, with the lateral segments bifid and showing evidence of further subdivision on the posterior side, cordate at the base; ultimate lobes and teeth mucronate.

Ultimate leaves palmately five- to nine-lobed; middle lobe cuneate, trifid, and cut or incise-serrate; lateral lobes generally oblong, bi- to tri-fid, incise-serrate, or cut.

The seedlings of D. hybridum resemble those of D. elatum. In D. cardinale the petioles are connate at the base.

Delphinium nudicaule, *Torr. et Gray* (fig. 137).

Primary root tapering downwards, with a few lateral rootlets and abundantly covered with rusty-brown hairs.

Hypocotyl very short or suppressed, or indistinguishable from the root or together with the latter becoming fleshy, tapering downwards and forming the persistent rootstock of the plant.

Cotyledons ovate, acute, mucronate, five- to seven-nerved longitudinally, glabrous, pale green, connate by their bases and forming a little cup; petioles terete, erect, slender at the base and split on one side to allow the escape of the plumule, glabrous, pale green, 2–8 cm. long, connate through their whole length; lamina 6–12 mm. long, 3·5–9·5 broad.

Stem herbaceous, erect, twelve to eighteen inches long, elongating when about to flower; primary internodes undeveloped.

Leaves simple, palmately lobed, radical and cauline, alternate, exstipulate, palmati-nerved, bright green above, paler beneath, shining on both surfaces, petiolate; petiole terete, slightly flattened on the upper side, or channelled towards the apex, somewhat dilated at the base and sheathing, pale green, glabrous.

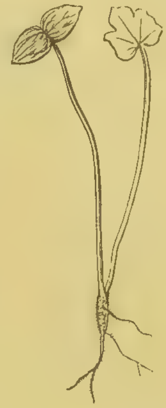

Fig. 137.—*Delphinium nudicaule.* Half nat. size.

No. 1. Palmately three- to five-fid, five- to seven-nerved, lobes generally cuspidate, teeth tipped with a glandular mucro.

Delphinium trollifolium has the petioles of the cotyledons united in the same way as D. nudicaule.

Delphinium Consolida, *L.*

Primary root similar to D. Staphysagria.

Hypocotyl erect, terete, glabrous, pale greenish-white or stained with red, tapering insensibly into the root, protruding 8–12 mm. above the soil.

Cotyledons broadly oblong-ovate, obtuse, entire, tipped with a pale-coloured mucro, glabrous, obscurely trinerved with the lateral nerves much branched, anastomosing, incurved and uniting with the midrib close to the apex, petiolate; petioles grooved above, convex on the back, dilated and connate at the base, 9·5–12 mm. long; lamina 12–13·5 mm. long, 7–9 mm. wide.

Stem herbaceous, annual, elongating when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, tri-partite or -sect, with the venation ramifying accordingly, and obscurely reticulate, pubescent on both surfaces when young, glabrescent, light green and opaque above, paler beneath and somewhat shining, petiolate; petioles semiterete, channelled above, dilated and amplexicaul at the base, tapering upwards.

No. 1. Palmately tripartite with nerves running into the primary and secondary segments; middle segment cuneate, trifid with obtuse mucronate secondary segments; lateral segments obliquely cuneate, twice bifid, with oblong obtuse mucronate secondary segments.

No. 2. Palmately tri-partite or -sect; middle lobe rhomboid-cuneate, trifid with its middle segment again trifid, and its lateral ones unequally bifid; lateral lobes obliquely cuneate bipartite with the anterior segment unequally trifid and the posterior segment unequally bifid.

No. 3. Trisect; middle lobe broadly palmately-cuneate and divided almost like the first leaf; lateral lobes similar in outline, smaller and somewhat less cut.

No. 4. Multisect.

Delphinium Ajacis, *L.*

Primary root as in D. Staphysagria.

Hypocotyl as in D. Consolida.

Cotyledons elliptic-oblong, obtuse, terminated by a glandular mucro, very similar to those of D. Consolida, but with a longer petiole, of 10–17 mm.

Stem as in D. Consolida.

Leaves as in D. Consolida.

No. 1. Tripartite; segments elliptic or oblong-elliptic, entire, tipped with a pale-coloured glandular mucro, the terminal one broadest, and the lateral one sometimes bifid.

No. 2. Similar, larger, generally with the lateral, sometimes with all the segments bifid.

No. 3. Palmately trisect; middle segment rhomboid-cuneate, deeply trifid; lateral segments obliquely cuneate, obliquely or unequally bi- or tri-partite.

Nos. 4 and 5. Trisect; middle segment cuneate, palmately trisect and sparingly lobed—lateral lobes or segments obliquely bisected with their anterior halves deeply trifid, and their posterior halves deeply bifid.

Note.—One or both of the cotyledons are sometimes bifid or parted to the very base, simulating three or four cotyledons in the latter cases.

Aconitum cernuum, *Koell.*

Hypocotyl short and subterranean.

Cotyledons oval-oblong, acute, entire, glabrous, light green, trinerved, petiolate; petioles very long, channelled on the upper side, 3–3·5 cm. long.

Stem with primary internodes undeveloped.

Leaves simple, palmatifid, radical, alternate, exstipulate, petiolate, glabrous, light green, cordate at the base, trinerved; lobes acute, usually divided into two to three secondary lobes or trifid.

DILLENIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 10.

The ovules are one or many, anatropous and ascending. The raphe is ventral as in the Ranunculaceæ, and probably for the same reason. The seeds are single or few, and generally provided with an aril. The embryo is minute with the radicle inferior, near the hilum.

The members of this order being chiefly natives of the southern hemisphere, and but few of them popular hothouse plants, are seldom raised from seeds in this country; consequently but little opportunity is afforded for observations on the cotyledons. Those of Hibbertia dentata are linear-lanceolate, sessile, narrowed to the base, where they are shortly connate and sheathe the young stem, persistent, somewhat coriaceous, 20 mm. long, and 5 mm. broad. The persistent nature and subcoriaceous texture are characteristic of genera and species of arboreal or shrubby habit with evergreen leaves. The Dilleniaceæ are either trees or shrubs, sometimes twiners, rarely suffruticose or herbs.

Hibbertia dentata, *R. Br.*

Hypocotyl succulent, 1–2 cm. long, 2 mm. thick, terete, glabrous, pink near the base, green above.

Cotyledons sessile and forming a short sheath round the base of the first internode of the stem, 2 cm. long, 5 mm. broad, linear-lanceolate, mucronate, with sunk midrib, glabrous, rather firm and persistent, dark green above, paler below.

Stem terete, 2 mm. thick at the first internode, which is about 1·5 cm. long; the successive internodes gradually increase in length and thickness, hirsute, reddish, but green under the sheathing petioles and seed-leaves.

Leaves simple, cauline, alternate, exstipulate, alternately penninerved, nervation reticulate, glabrous except at the margin and on the principal nerves beneath, deep green above, paler beneath, often stained red in the adult plant; petiolate, petioles short, deeply channelled above and partly sheathing the stem.

No. 1. Small, oblong, obtuse, nearly entire.

Nos. 2–4. Oblong, acute, margin shallowly dentate with the teeth slightly recurved, somewhat oblique at the base.

CALYCANTHACEÆ.

Benth. et Hook. *Gen. Pl.* i. 15.

Fruit and Seed.—The fruit is an achene containing an oblong or obovoid seed. Several fruits, or few by abortion, are surrounded by the deeply cup-shaped thalamus or receptacle, which increases in size and persists till the seeds are ripe. The seeds are exalbuminous, being wholly occupied with the large embryo, the cotyledons of which are convolute, of very unusual outline. The short radicle is close to the hilum of the anatropous seed.

Cotyledons.—Two genera, including in the aggregate only four well-marked species, constitute the whole of this small Order. They differ widely in the characters of the embryo from all the allied Orders, but show a certain amount of affinity with Magnoliaceæ through Illicium. The cotyledons are longitudinally convolute, like a roll of manuscript, in both genera, and together with the radicle and embryo occupy the whole of the seed. Those of Calycanthus macrophyllus are apparently unsymmetrical, almost transversely oblong, with a broad, shallow apical sinus, a narrower and deeper sinus at the base, and a notch above a small lobe at the base of the smaller half of each cotyledon.

Leaves.—Typically these are opposite, but occasionally they are slightly alternate by the development of the internode. Being simple and entire, with the principal nerves ascending and incurved, they present no very striking features. The two first pairs of Chimonanthus fragrans are very small.

almost rudimentary, and recall what may be seen in many species belonging to widely separated Orders, which have subterranean cotyledons. Instances occur in Clematis recta (fig. 120), Rhus Thunbergiana (fig. 255), Lecythis Sapucajo, Quercus pedunculata, the Walnut, and many others, the congeneric species of some of which have aerial cotyledons.

The explanation is probably that when a large store of reserve food-material is laid up in fleshy cotyledons, the plant is able to form a considerable length of stem independently of well-developed leaves. In Chimonanthus the cotyledons are fleshy, but they are aerial, and well exposed to light by being elevated on a hypocotyl 3–4·5 cm. above the ground.

Chimonanthus fragrans, *Lindl.*

Fruit an achene, oblong, deep brown, almost black, 17 mm. long, 8–9 mm. broad.

Hypocotyl woody, erect, terete, glabrous, greenish-yellow, 3–4·5 cm. above soil.

Cotyledons large, foliaceous, convolute in the seed, after germination broader than long, petiolate, deeply auricled at the base, auricles incurved, obscurely trinerved and reticulate-veined, glabrous, fleshy and very brittle, bright green above, paler or yellowish-green beneath, 2·6 cm. long, 3·8 cm. broad. They persist for more than a year.

Stem woody, erect, terete, glabrous, thinly dotted with lenticels, pale green; 1st internode 1·65 mm. long; 2nd 2·4 cm.; 3rd 2·2 cm.; 4th 3·25 cm.; 5th 4·25 cm.

Leaves simple, entire, cauline, opposite (sometimes alternate), exstipulate, petiolate, hairy on the margin and beneath the midrib, ultimately becoming glabrous but very rough and scabrous, alternately and irregularly penninerved, pale green above, paler beneath, shining; petioles short, slightly channelled above, convex beneath, slightly hairy or scabrous on the upper margins, otherwise smooth.

First pair small, scale-like and perishing early.

Second pair similar or sometimes foliaceous and subdimidiate, or very unequally developed on each side of the midrib, deeply and obliquely emarginate, with rounded points.

Third pair foliaceous, subobovate, obliquely and deeply emarginate, with rounded lobes.

Fourth pair lanceolate, acuminate, 12·65 cm. long, including the petiole.

Fifth pair oblong-lanceolate, acuminate, shorter than the last because on the tip of the shoot, which has finished growth for a season.

Ultimate leaves ovate, acuminate, entire, scabrous.

MAGNOLIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 16.

The Magnoliaceæ are trees or shrubs. The leaves are simple and entire or dentate, with an ascending, incurved, penninerved, and reticulate venation. They are leathery and evergreen, or membranous and deciduous, and often have aromatic oil glands. The seeds of Drimys and Illicium have a shining black testa. In Magnolia they are drupe-like, with the outer coat fleshy and the inner one crustaceous. When the follicles containing them dehisce, they do so along the dorsal suture in Magnolia, Manglietia, and Michelia, allowing the seeds to drop out, suspended by a long, filiform funicle. The seeds are generally fairly large, and contain a copious, oily endosperm. The embryo is small or minute with diverging cotyledons. In the Tulip-tree (Liriodendron) the seed is contained in a persistent samaroid carpel.

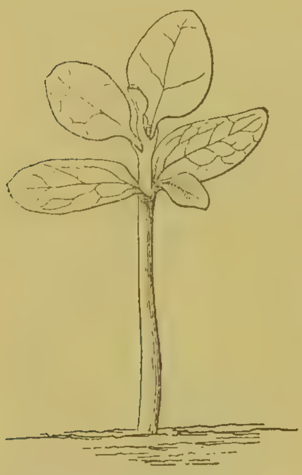
FIG. 138.—*Drimys Winteri*, × 2

The cotyledons of Drimys Winteri (fig. 138) are oblong, ovate, obtuse, obscurely trinerved and reticulate, punctate with pellucid glands, and rather persistent. The seedlings are of slow growth. The first leaf is several times smaller than the cotyledons; and the succeeding two are roundish or ovate, and nearly the size of the latter.

Drimys Winteri, *Forst.* (fig. 138).

Hypocotyl erect, terete, glabrous, pale green, 11–14 mm. long.

Cotyledons oblong-ovate, obtuse, entire, shortly petiolate, glabrous, bright green above, glaucous beneath, with pellucid glandular dots; obscurely trinerved and reticulate; petiole flattened above, convex beneath, ·5 to 1 mm. long; lamina 7–9 mm. long, 3·45 mm. wide.

Stem erect, terete, glabrous, pale green, ultimately woody; 1st internode undeveloped or ·25–1 mm. long; 2nd and 3rd each 1–1·5 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, alternately penninerved, with the nerves incurved and uniting some distance within the margin, and anastomosing beyond, glabrous, deep green above, glaucous beneath; petiole flattened above or shallowly grooved, convex or rounded on the back, very short.

No. 1. Broadly ovate or oval, obtuse, very small.

Nos. 2–4. Similar and gradually larger, sometimes rotund.

Ultimate leaves oblanceolate-oblong, acuminate, obtuse, alternately and ascendingly penninerved, obscurely reticulate, light or deep green above, glaucous beneath; coriaceous, evergreen, 5–8 inches long, 1–1½ inches broad.

ANONACEÆ.

Benth. et Hook. *Gen. Pl.* i. 20.

Fruit and Seed.—The carpels are generally numerous. The ripe fruit is either dry and dehisces like a follicle with two valves as in Anaxagorea; baccate, one-celled and one-seeded as in Polyalthia; woody and one-celled with the seeds embedded in pulp as in Monodora; or fleshy and united into a large multilocular indehiscent fruit as in Anona. The fruit is rarely dehiscent in the Order, and the seeds are generally of large size, sometimes arillate. There are one or two erect, anatropous ovules in each cell with the raphe ventral, or the ovules are numerous and arranged in one or two rows along the ventral suture. In the species of Anona the ovules are solitary in each cell, and the seed attains a large size, is broadly oblong and more or less compressed laterally. The outer coat is thick and corky or subwoody, while the inner one is invaginated, *i.e.* dips deeply into the fleshy and copious endosperm, making it ruminated. The embryo in the mature seed is small and situated close to the hilum, embedded in endosperm. The ruminated character of the endosperm is common to the Order.

The seeds differ greatly even in nearly allied species. Thus in Oxymitra patens they are globular with numerous blunt processes; in O. Grayana they have two, in other species four wings, while others again are round and smooth.

Cotyledons.—The seedlings of Anona are strong and vigorous but present a singular anomaly, inasmuch as the cotyledons are in some species torn from the axis during germination. The seeds of A. laurifolia split longitudinally, the strong radicle strikes straight downwards fixing the seedling firmly in the soil, and the hypocotyl forms an ascending or elongating loop. The large seed remains underground, while the hypocotyl at length pulls out the plumule, and straightens, leaving the cotyledons behind. If a seed is cut open at this point the cotyledons are seen to be oblong or oval, obtuse, petiolate, almost equalling the length and breadth of the seed, and much undulated or wrinkled in order to accommodate themselves to the inequalities of the much ruminated endosperm. They exhibit an ascending, incurved, feather-nerved venation very similar to that of the leaves, and at this stage are surrounded or included between two equal halves of the endosperm with a small quantity of the same between them. A. Cherimolia behaves in exactly the same way, and the cotyledons are invariably torn from the axis and left in the subterranean seed.

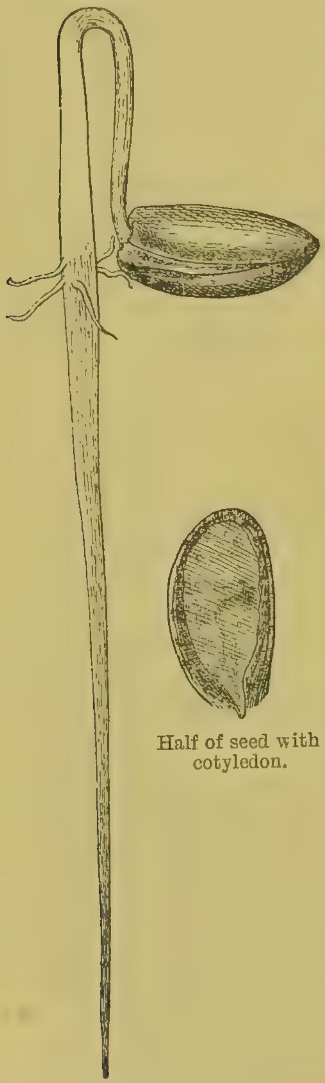
Half of seed with cotyledon.

Fig. 139.—*Anona, ? laurifolia.* Nat. size.

A. palustris is an exception to the other species examined, inasmuch as the cotyledons become aerial. They are oval, or oblong-elliptic, obtuse, petiolate, foliaceous, with a penninerved, incurved venation, and in every respect similar to that of a true leaf with the exception that the leaves are acuminate.

Anona, ? laurifolia, *Dunal* (fig. 139).

Primary root very long, fleshy, thick, colourless, penetrating the soil perpendicularly to a great depth, furnished with short stout horizontal lateral rootlets at the base of the hypocotyl, and immediately beneath the soil or at the depth the seed was buried before germination.

Hypocotyl long, stout, tapering upwards, glabrous, mottled and streaked with red on a pale or colourless ground, giving the whole a pale brown or brownish-red appearance, 8–9·5 cm. long, rising in the form of a loop during germination.

Cotyledons oblong, obtuse, petiolate, glabrous, very small in the seed, but during germination increasing almost to the length and breadth of the seed, and becoming much wrinkled and undulated to conform to the inequalities of the much ruminated ends, finally becoming separated from the axis when the hypocotyl has attained a considerable size, and remaining embedded in the subterranean seed between two equal halves of the endosperm, with a thin layer of endosperm between them ; lamina 1·5 cm. long, 8 mm. broad ; petiole 5–6 mm. long.

Stem woody, erect, terete, hairy, with ascending adpressed hairs.

Leaves simple, entire, cauline, alternate, distichous, exstipulate, petiolate.

Anona Cherimolia, *Mill.*

Hypocotyl erect, terete, tapering upwards, stout, slightly glabrous, pale green, 5·5–7 cm. long.

Cotyledons retained in the seed, which is subterranean, while the hypocotyl straightens without them.

Stem as in preceding species ; 1st internode 5·5 mm. long.

Leaves simple, entire, cauline, alternate (first two sometimes opposite), exstipulate, petiolate, alternately or almost oppositely penninerved and reticulate, with the nerves incurved towards their ends and uniting with those next above them, glabrous or nearly so above, ciliate and more or less hairy beneath ; petioles semiterete, channelled above, hairy, with adpressed hairs.

Nos. 1 and 2. Alternate or subopposite, oblong-ovate, obtuse, revolute at the margin, light green slightly glaucous above, glaucous beneath.

Anona palustris, *L.*

Hypocotyl as in A. Cherimolia, but reddish-green ; 9 cm. long.

Cotyledons aerial, oval or oblong-elliptic, obtuse, entire, shortly petiolate, glabrous, dark shining green above, paler beneath, slightly reflexed, about 25 mm. long, 6–12 mm. wide, with a distinct midrib and numerous veinlets, united at their tips, giving the appearance of two lateral veins. In other species of this genus the cotyledons usually remain within the seed.

Stem herbaceous, erect, terete, glabrous, light green; 1st and 2nd internode 5–10 mm. long.

Leaves lanceolate, acuminate, otherwise as in A. Cherimolia.

MENISPERMACEÆ.

Benth. et Hook. *Gen. Pl.* i. 30.

Fruit and Seed.—The carpels are free and ripen into baccate or drupaceous fruits. The placental or ventral suture of the endocarp enlarges or thickens into a hemispherical process projecting into the cavity of the ovary and determines the shape of the seed. The endocarp is also considerably flattened laterally and forms a strong submarginal moon-shaped ridge on both surfaces close to the outer or dorsal suture. This ridge lodges the correspondingly thickened part of the seed containing the embryo.

The ovule is amphitropous almost throughout the Order and is peltately affixed to the enlarged or hemispherical placenta. In a very few cases it is anatropous. The seed is generally crescent-shaped. The endosperm is fleshy and moderately copious in the Tinosporeæ and Cocculeæ, but scanty in the Cissampelideæ, and absent in Pachygoneæ.

In the first tribe above mentioned there is considerable range of variety in the shape of the embryo. The cotyledons of Aspidocarya are flat, spreading at the base, and parallel above; those of Parabæna and Tinospora are ovate and diverging laterally, those of Anamirta are narrow, very slender and diverging, while Coscinium has a fleshy, much ruminated endosperm, a short, nearly straight embryo, with slender, diverging, deeply sinuately-laciniate cotyledons.

The embryo in the tribes Cocculeæ and Cissampelideæ is cylindrical with adpressed cotyledons, and resembles that of Menispermum (fig. 140) with the exception that it is straight in some instances as in Anomospermum. The seeds of the Pachygoneæ are exalbuminous, while the embryo differs chiefly from that of Menispermum in being thick, fleshy, and occupying the whole cavity of the seed.

Cotyledons.—There is a great amount of variety in the cotyledons of the different genera belonging to this Order, but few of them come under observation in a living state from the fact that most of the species are members of tropical regions and are of little or no horticultural value.

A large number of species conform however to Menispermum. It is probable that the cotyledons of some members of the Order would prove subterranean on germination, as for instance in the case of Tiliacora, the embryo of which nearly equals the seed in length, and has fleshy adpressed cotyledons. They are also fleshy and thick in Hyperbæna, cortical and fleshy in Fibraurea, as well as in some others belonging to the tribe Pachygoneæ.

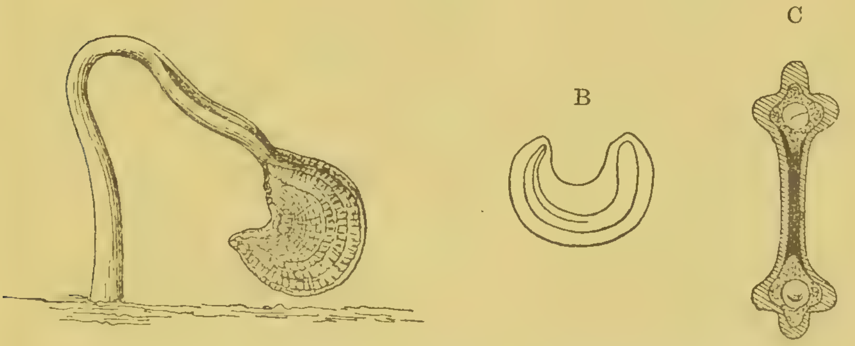

FIG. 140.—*Menispermum canadense*: A, germinating seedling, × 2; B, vertical section of seed, × 2; C, transverse section of seed, × 4.

Menispermum canadense, *L.* (fig. 140).

Fruit drupaceous, one-seeded, black or bluish black when mature, laterally compressed; endocarp bony, laterally compressed, reniform or horseshoe-shaped, crested along the dorsal edge.

Seed attached to the ventral indented process of the endocarp and conforming to it in shape; testa thin; hilum on the middle of the ventral edge.

Endosperm fleshy, copious, surrounding the embryo, creamy white or yellow.

Embryo linear, much curved in conformity with the seed, fleshy, colourless or yellow; cotyledons linear or semiterete, obtuse, applied to each other, face to face, with their backs to the ventral suture of the fruit and their edges in consequence at right angles to the plane of the seed, a little longer than the radicle; radicle cylindrical, obtuse, superior, and close to the base of the style.

Seedling (fig. 141).

Hypocotyl sub-erect, rather firm, about 2·5 cm. long, 1·5 mm. thick, terete, glabrous.

Cotyledons sessile, semi-erect, about 3 cm. long, 1–2 mm. broad, semiterete, entire, obscurely nerved, twisted, glabrous, pale green, caducous.

Stem slender, twining, the first few internodes 5–7·5 mm. long, 1 mm. thick, terete, glabrous, light brown.

Leaves simple, cauline, alternate, exstipulate, petiolate, more or less lobed or angled, peltate, palmatinerved and reticulate, glabrous, membranous, more or less glaucous above, paler beneath with a glaucous bloom; petiole terete, slightly tapering upwards, glabrous.

No. 1. Peltate, cordate at the base, more or less obtusely five-angled, radiately five- to seven-nerved and closely reticulated.

No. 2. Similar, but often smaller, three- to five-angled, shallowly cordate at the base.

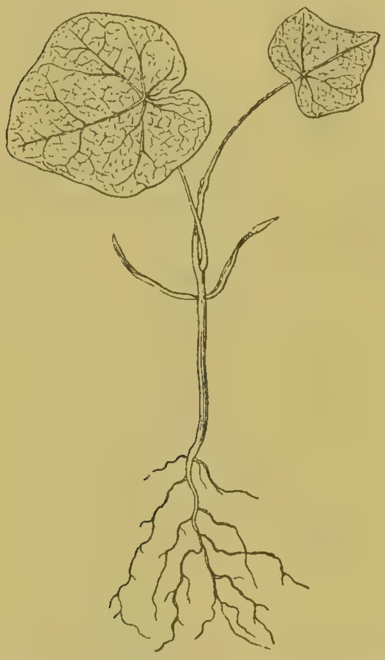

Fig. 141.—*Menispermum canadense.* Half nat. size.

BERBERIDEÆ.

Benth. et Hook. *Gen. Pl.* i. 40.

Fruit and Seed.—The fruit of the Berberideæ is a berry or capsule. The ovules are two to indefinite, very rarely solitary, generally anatropous and erect, with the raphe ventral, sometimes orthotropous. The seeds contain a copious, fleshy or somewhat hard endosperm; and the embryo is frequently small as in Lardizabala, Caulophyllum, and Nandina, but is occasionally of medium size as in Berberis (fig. 142). In the latter the embryo is nearly three-quarters as long as the seed, and has a terete radicle with broadly ovate, obtuse, emarginate cotyledons. The notch is exceptionally large in this instance, and I could see nothing in the structure of the seed to account for it. It is moreover often altogether absent; but, when present, is apparently due to the slower growth of the organic apex. The seed itself is bluntly triangular in transverse section, and shows the cotyledons lying in the broader plane of the seed, but not always strictly in apposition, a circumstance possibly due to the squeezing produced by the endosperm, while the cavity is a little wider than the embryo it contains. The shape of the seed is due to the mutual pressure of several seeds in a berry or fruit. Either the dorsal aspect of the seed, or the sides, may be the broadest according to the position of the same on the placenta. The general shape of seeds in the order is obovoid, oblong, or globose, and they are generally immersed in pulp without being subject to much pressure when mature.

Cotyledons.—The cotyledons are generally oblong, obtuse, shortly petiolate or subsessile, deep green, glabrous, subcoriaceous, with a few slender, ascending, and generally slightly emarginate veins.

A remarkable type is found in Podophyllum Emodi, a low, creeping or rhizomatous herb from the Himalayas. The blades of the cotyledons are roundly oval, entire or minutely emarginate, with a small tooth in the notch, five- to seven-nerved and faintly reticulated and spring horizontally from the apex of a common, terete, rather slender petiole, about 2 inches in length, formed by cohesion of the original two. The petiole splits by a lateral fissure close to the base to allow the exit of the plumule. Instances of this have already been given in Ranunculaceæ.[1]

Berberis Aquifolium, *Pursh.* (fig. 142).

Fruit baccate, ovoid or ellipsoid, glabrous, deep purple, black when mature and covered with a glaucous bloom tipped with the short stout style and annular stigma, one-celled; seeds four to six or fewer, seldom more; mesocarp juicy, deep vinous purple; endocarp thin, membranous.

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[1] *v.* Anemone.

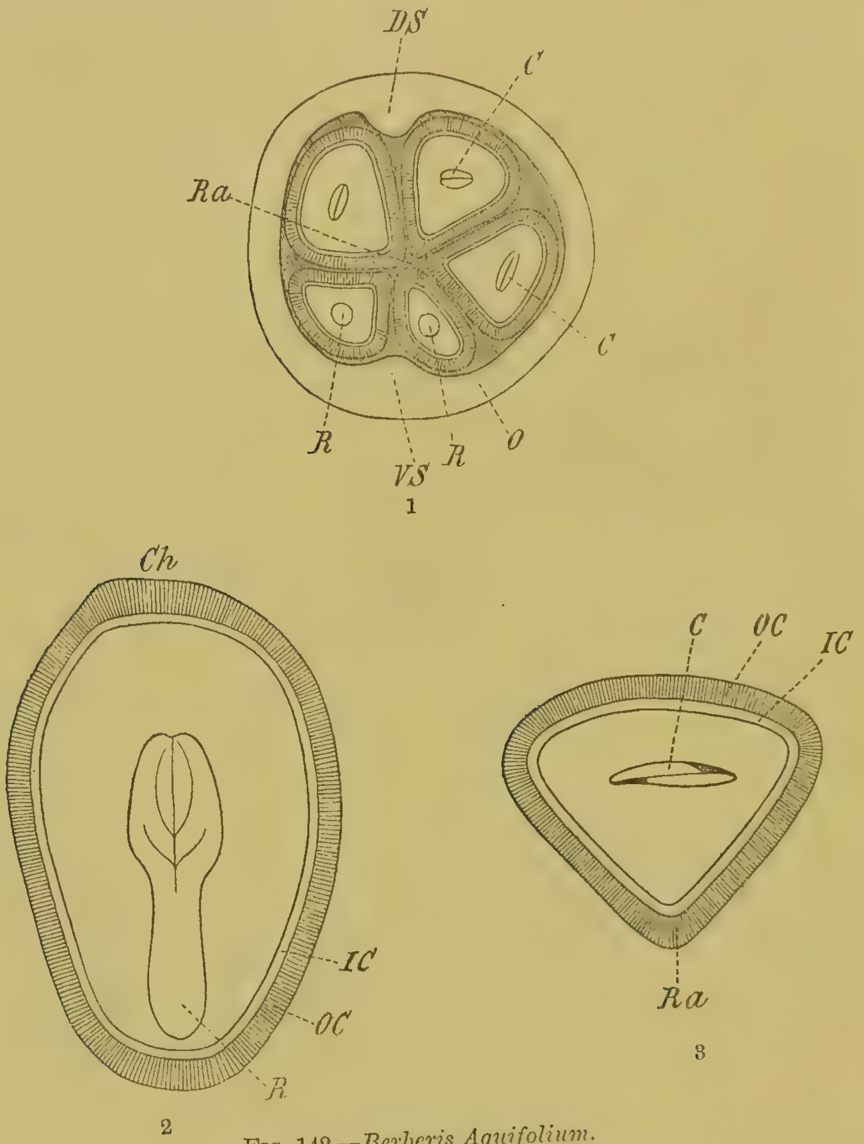

Fig. 142.—*Berberis Aquifolium.*

1, Transverse section of fruit, × 5: *D S*, dorsal suture; *Ra*, raphe; *R R*, radicles; *C*, *C*, cotyledons; *V S*, ventral suture; *O*, ovary wall or pericarp.

2, Longitudinal section of seed, × 10: *Ch*, chalaza; *R*, radicle; *O C*, outer coat (testa); *I C*, inner coat (tegmen).

3, Transverse section of seed, × 10: *C*, cotyledon; *O C*, testa; *I C*, tegmen; *Ra*, raphe.

Seed oblong-obovoid, obtusely trigonous, or sometimes variously angled by mutual pressure, broadest on the dorsal aspect or the sides according to position (the latter generally characterises those seeds towards the upper end of the placenta), pale brown, glabrous, shining; testa thick, coriaceous; tegmen thin, membranous; hilum and micropyle contiguous, basal, the hilum forming a round or oval depressed cavity with a thickened dark margin; raphe ventral, forming a thickening on the ventral angle; chalaza apical, conspicuous.

Endosperm in the mature seed copious, fleshy, white.

Embryo considerably shorter than the endosperm, straight, colourless; cotyledons oval, obtuse, minutely emarginate, otherwise entire, sessile, trinerved at the base, then again from below the middle to the apex, where the lateral nerves unite with the midrib, and are themselves slightly branched; nearly or quite flat, and applied to one another face to face, or frequently pushed apart with the edges overlapping, lying in the broad way of the seed with their backs to the placenta; radicle cylindrical, obtuse, or thickest near the point, about as long as the cotyledons, embedded in the endosperm close to the micropyle.

There are sometimes three cotyledons; and in other cases, by proliferation, a second and smaller embryo is produced, closely applied to the larger and perfect one.

Seedling (fig. 143).

Hypocotyl woody, erect, terete, about 3·6 cm. long.

Cotyledons oblong, obtusely pointed, narrowed into the petiole, glabrous, 1·5 cm. long, 5 mm. broad.

Stem woody, erect, lower internodes undeveloped.

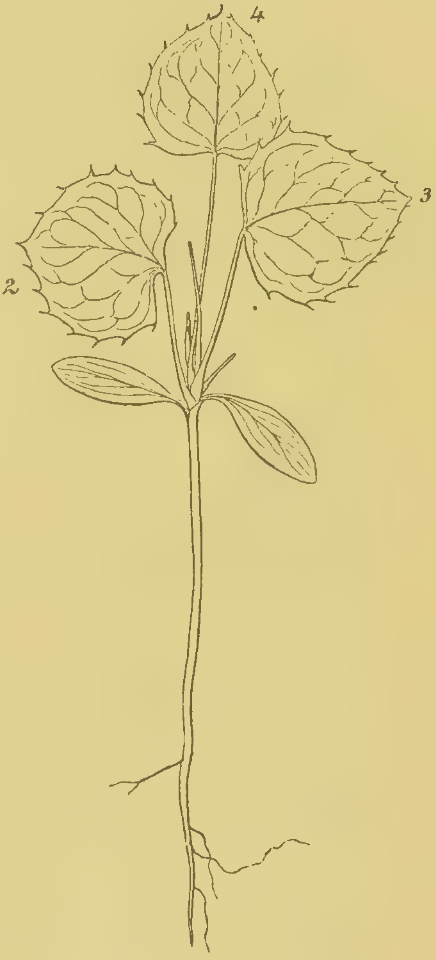

Fig. 143.—*Berberis Aquifolium.* Nat. size.

Leaves simple in the seedling stage, ultimately imparipinnate, cauline, alternate, stipulate, petiolate, glabrous, coriaceous, reticulately nerved, deep green above, glaucous beneath; petioles filiform, wiry, dilated and sheathing at the base, articulated with the lamina; joint swollen; stipules adnate to the petioles with a small, subulate, acute, free point.

No. 1. Reniform, cuspidate, minutely spinous-serrulate.

No. 2. Reniform, cuspidate, finely spinous-serrate, five-nerved at the base.

Nos. 3 and 4. Cordate, finely spinous-serrate, five-nerved at the base.

No. 5. (In a second specimen) unequally bi-foliolate; terminal leaflet obliquely ovate, spinous-serrate; lateral leaflet obliquely oblong-ovate, obtuse, cut away from the base of the terminal one.

No. 6. Trifoliolate; terminal leaflet oval, spinous-serrate; lateral leaflets obliquely ovate, spinous-serrate.

Subsequent forms are three- to five-foliolate; lateral leaflets oblong, ovate, acute, spinous-serrate; terminal leaflet oblong-cordate, or simply ovate, acute, spinous-serrate.

Ultimate leaves three- to nine-foliolate; lateral leaflets obliquely ovate, cut away on the upper side at the base; terminal one ovate; all spinous-serrate with slightly repand teeth.

Berberis erecta, *Auct.*?

Hypocotyl similar to that of B. Aquifolium.

Cotyledons subsessile, 1·25–1·5 cm. long, 4–5 mm. broad, linear-oblong, obtuse and emarginate, alternately and ascendingly nerved, glabrous, thin, coriaceous, dull dark green on the upper side, lighter and shining beneath.

Stem firm, terete, glabrous, brownish green, internodes very short.

Leaves, Nos. 1–10. Alike, simple, cauline, alternate, petiolate, alternately nerved and reticulate, glabrous, coriaceous, deep green above, paler beneath; margin spinous-serrate; petioles slender, wiry, more or less sheathing at the base or stipulate.

Berberis vulgaris, *L.*, *var.* sulcata.

Hypocotyl as in B. Aquifolium, 1 cm. to 2·5 cm. above the soil.

Cotyledons oblong, obtuse, coriaceous, shortly petiolate, 1·25 cm. long, 6 mm. broad; petiole 1·5 mm. long.

Stem woody, erect, terete, glabrous, thickened at the nodes, pale green suffused with red; internodes very irregularly developed; first three to nine undeveloped: in specimen described first three undeveloped; 4th internode 5·5 mm. long; 5th 1 cm.; 6th 4·5 mm.; 7th–10th undeveloped.

Leaves simple, cauline, alternate, stipulate, petiolate, glabrous, spinous-serrate with the spines directed alternately upwards and downwards forming two rows; petioles filiform, slender, reddish, glabrous, dilated and amplexicaul at the base; stipules minute, nearly wholly adnate to the sheath of the petiole.

No. 1. Ovate, cordate, obtuse.
No. 2. Reniform.
No. 3. Broadly cordate, obtuse.
Nos. 4–6. Cordate, obtuse.
No. 7. Small, rotund-cordate.

Berberis concinna, *Hook. f.*

Hypocotyl erect, terete, glabrous, 3·5–4 mm. long, yellowish-green.

Cotyledons oval or oblong, slightly emarginate, fleshy, petiolate, with short broadish petioles, glabrous, dull green; midrib with numerous ascending branched veinlets, similar to the venation in the leaves.

First leaves opposite, ovate, or subrotund, spiny, shining green above, glaucous-green below, otherwise as in the preceding species.

Berberis sibirica, *Pall.*

Hypocotyl very similar to that of B. Aquifolium.

Cotyledons very similar to those of B. concinna. The emarginate character is at first very slight or altogether wanting.

Stem erect, terete, herbaceous, ultimately woody; 1st and 2nd internodes but slightly developed; 3rd 3–4 mm. in length; 4th exceedingly short.

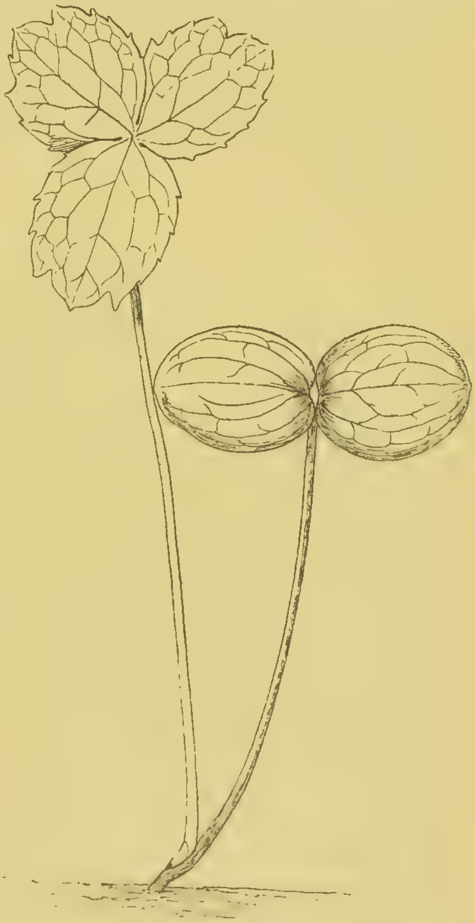
FIG. 144.—*Podophyllum Emodi.* Nat. size.

First leaves very similar to those of B. vulgaris.

Podophyllum Emodi, *Wall.* (fig. 144).

Hypocotyl undeveloped.

Cotyledons broadly oval or rotund-oval, entire or minutely emarginate, with a small tooth in the notch, five- to seven-nerved and faintly reticulate, glabrous, convex above, margin revolute, light green above, pale beneath, shining on both surfaces; lamina 17 mm. long, 14·5 mm. wide; petioles connate into one terete stalk, thinly and minutely pubescent, pale green, shining, split on one side at the base to allow the plumule to escape, 4·9 cm. long.

Stem herbaceous, forming an underground rhizome; 1st and following internodes undeveloped.

Leaves simple, peltate, radiately or palmately-nerved and partite, radical, alternate, exstipulate, petiolate, glabrous or thinly ciliate, with the lobes one-nerved and strongly reticulate; petiole terete (at least in the seedling stage), glabrous, pale green, erect.

No. 1. Tripartite, with the segments radiating equally in form of a triangle; lobes oval, obtuse, mucronate, irregularly, acutely, and mucronately serrate, the terminal one slightly the largest.

NYMPHÆACEÆ.

Benth. et Hook. *Gen. Pl.* i. 45.

Fruit and Seed.—Carpels three to many, free or more or less immersed in the torus, indehiscent when mature and distinct or united to form a fleshy and spongy or pulpy fruit. Ovules one to many, anatropous, pendulous. The embryo in Nelumbo occupies the whole seed, while in the rest of the Order it is very small and there is both endosperm and perisperm. Such cases are very rare; they occur also in the Piperaceæ and in the Zingibereæ, a tribe of the Order Scitamineæ. In the Nymphæaceæ, however, the seed is almost entirely occupied with perisperm, the endosperm being reduced to a thin layer forming a more or less fleshy amniotic sac enclosing the embryo at the apex of the perisperm. The seeds are usually anatropous, but in a fruit of Nuphar some may frequently be found that are orthotropous. The seeds are very numerous in Nymphæa, Victoria, and others, and are scattered all over the walls or septa of the ovary. They are few in Cabomba, Brasenia, Euryale, and one to two in each carpel or nut of Nelumbium. The ripe seeds are often covered with a pulpy or fleshy aril, which in Euryale is large and fleshy, and serves to float the seeds after liberation from the spongy, baccate fruit, until it bursts or gets broken, when the seeds immediately sink.

The embryo of Cabomba differs from that of Nuphar or Victoria in being shortened, flattened, and rhomboid in vertical section with a scarcely discernible caulicle connecting the cotyledons.

The seeds of Nelumbium differ from all others of the Order in being exalbuminous. The seed contains an embryo consisting of two large, hemispherical, fleshy cotyledons connected by the caulicle or primary axis. Between these is a strongly developed plumule, the leaves of which are closely longitudinally involute at the margins. The petiole is also bent backwards in the direction of the radicle. Germination is very rapid after access of water to the embryo and takes place in a very few days if a small hole is artificially made in the woody pericarp.

Cotyledons.—The typical cotyledons of this Order as far as observed are subterranean—that is, remain in the seed even after germination. Nymphæa, Victoria, and Euryale may be given as examples. Another type is seen in Nelumbium, which, alone in the Order, has exalbuminous seeds. These are larger than any other of the Nymphæaceæ, and contained in a thick and lignified pericarp, while the embryo occupies the whole of the interior, to which it conforms. The cotyledons are hemispherical and lodge between them the greatly enlarged or advanced plumule. They are also subterranean during germination, serving merely as a storehouse of reserve-material.

Leaves.—The leaves of most species of the Order are floating and exhibit but a few types. Seedlings are generally heterophyllous, a circumstance of frequent occurrence amongst aquatic plants whether phanerogams or cryptogams. In the adult state of the plants, all of which are aquatic or marsh-loving herbs, four distinct types may be given, namely, those which are oblong, orbicular, scutiform, or subsagittate, represented by Nymphæa and Nuphar; secondly, peltate and floating leaves, as seen in Brasenia, Victoria, and Euryale; thirdly, peltate and aerial leaves, exhibited by Nelumbium; and lastly, the finely-divided submerged leaves of Cabomba, which are palmately cut up into slender thread-like segments, resembling those of some forms of Ranunculus aquatilis. The floating leaves of Cabomba are peltate and orbicular.

The stages of the advancing seedling from the juvenile to the adult state, with regard to the leaves, may be readily examined in Nymphæa, Victoria, or Euryale. The seedling of Nymphæa Lotus, var. thermalis, in germination throws down a long root (primary root) into the soil or mud, while the first internode of the plumule grows a little and gives off the first leaf, which is short, slender, and filiform. The first leaf in other species is often longer than in this case. The second, third, and fourth leaves are oblong, lanceolate, obtuse, and all submerged in the water where the seedlings germinated. The ultimate leaves are peltate, orbicular, wavy at the margin, but the basal sinus is open, or at least not connate.

The primary leaves of Victoria and Euryale are even more varied, and, like those of Nymphæa, are produced in a rosette. The first internode in both these genera is more elongated than in the Nymphæa described, while the succeeding ones are undeveloped. From the base of this rosette, strong, adventitious roots are developed, which soon supplant the primary root. The first leaf of Victoria is filiform and slender, without a spreading blade; the second is narrowly oblong and petiolate; the third is hastate, petiolate, with a long, slender point; and the fourth is oval in outline, peltate, with the basal sinus partly connate, and furnished with a petiole capable of elongating to 18 or 24 inches or even more, according to the depth of the water in which the seedlings have germinated.

The seedling of Euryale ferox behaves in exactly the same way as that of Victoria, but the second and third leaves are rather stronger and broader. The whole seedling is larger, due no doubt to the larger seed and greater amount of reserve food-material at its command. The fourth leaf in both cases is a floating one and marks a great advance in the development of the plant. The three primary ones are always submerged, at least when the water is deep enough, and probably indicate the ancestral forms through which the leaves have passed to their present condition in the adult plant. After the fourth, which is regularly the first floating leaf in both Victoria and Euryale, the succeeding ones become connate along the whole of their basal edges, attaining a perfectly orbicular form by rapid stages. Those of Victoria become turned up at the edges after the plant has reached a considerable size, while those of Euryale always remain flat, merely increasing in diameter. The largest leaves of Victoria are from 6 to 7 feet across, with a circumference of 18 to 21 feet, perfectly orbicular, with the edges turned up to a depth of from 3 to 6 inches.

The peltate and aerial type of leaf is exhibited by Nelumbium speciosum, whose strong terete petioles vary from 3 to 6 feet in height, bearing at the top a nearly horizontal, peltate, orbicular, umbilicate, glaucous-green lamina, 12, 18, or more inches in diameter.

Finely-cut leaves occur only in the genus Cabomba, the greater number of which are submerged even in the adult state of the plant. Aerial, peltate, orbicular, and entire leaves seem to be developed chiefly from the apex of the stem when flowering, as the blooms are aerial. The leaves of Barclaya are linear, oblong, or orbicular, recalling in a measure the early stages of Nymphæa. The stem of Cabomba and Brasenia is slender and terete, with elongated internodes, whereas the stem of the other Nymphæaceæ forms a stout, fleshy rhizome or is shortened to a tuber.

Nymphæa Lotus, *L.*, *var.* thermalis.

Primary root very long, slender, with numerous root-hairs on the older part, which is brown, but with very few, and at first no, lateral rootlets. Strong adventitious roots are ultimately given off from the second node, below the leaves, and these finally supersede the primary root.

Hypocotyl tapering downwards and indistinguishable from the root proper, subterranean.

Cotyledons very small, remaining in the testa and attaching the young plant to the seed. Seed small, black, globose; testa reticulate.

Stem fleshy, forming a small black ovoid tuber or bulb-like rhizome.

Leaves simple, radical, alternate, exstipulate, petiolate, glabrous, coriaceous or subfleshy, deep green and shining above, pale beneath, midrib strongly protruding on the lower surface with many nerves radiating from its base, and given off alternately or suboppositely throughout its length; nerves ascending, forking, reticulate; petiole long, terete, glabrous, pale green, containing two large, central, semi-cylindrical cavities surrounded by eight small ones.

No. 1. Filiform, tapering to the tip and without a lamina, submerged, about 1 cm. long.

Nos. 2–4. Lanceolate-oblong, obtuse, rounded at the base, with a distinct midrib, brownish-green, finely mottled with purple on both surfaces, thin or membranous, submerged.

Ultimate leaves oval or orbicular, floating, slightly peltate by the union of their basal edges for about 1·4 cm.; with slightly diverging auricles, shallowly and acutely repand-dentate, with three nerves converging and entering each tooth, deep green and lucid above, paler beneath and marked with a few irregular discoloured blotches.

The germination of **N. alba** has been described by Tittmann, 'Denkschrift. der K. Baier. Bot. Ges.' Bd. ii. 1822, p. 101.

Nuphar lutea has also been described by Tittmann in the same memoir.

SARRACENIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 48.

Fruit and Seed.—The pistil is superior, syncarpous, with a three- to five-celled ovary made up of as many carpels. The placentation is axile, the numerous ovules are horizontal, anatropous, and arranged in many series. The fruit is capsular. The seeds are small, numerous, filled with a copious endosperm surrounding a minute embryo near the hilum. The testa is crustaceous, loosely reticulate, or bristly.

The seeds of Sarracenia are short, oblong, nearly or quite sessile, or with a finely reticulated testa, and a very stout raphe forming a deep ridge running along the whole of one side. The very minute embryo lies in the endosperm close to the hilum, and the cotyledons equal the radicle in length. The seeds of Darlingtonia californica[1] resemble long stalked club-like processes, provided especially at the apex with barb-like bristles. These are longest and strongest at the apical end.

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[1] See the figure, Le Maout and Decaisne, *System of Botany* (English translation), p. 213.

The seed itself is oval in outline, and the funicle terete or cylindrical. The embryo is also cylindrical and nearly as long as the endosperm. The cotyledons are plano-convex, and many times shorter than the radicle.

Seedling.—After germination the cotyledons increase greatly in length proportionately to their width. The hypocotyl is terete, slender, of considerable length, surmounted by the linear, acute, slender, one-nerved cotyledons, which are dilated and connate at the base, forming a little cup surrounding the plumule.

The first leaf of Darlingtonia californica[1] is narrowly linear, acute, and resembles the cotyledons; but is smaller and shorter. The second and third leaves are clavate, tubular, sheathing at the base, and ending in subulate, hooked, or incurved points.

The adult leaves vary from 12 to 18 inches in length, and are all radical, with the petiole tubular, twisted half round on its axis, furnished with a narrow wing on one side, on the edge of which are glands, vaulted, saccate, and recurved at the apex with the orbicular mouth on the lower side of the hood and facing downwards, striate longitudinally with parallel nerves and smaller ones between them; lamina at the lower and outer edge of the hood, narrowed at the base, with two oblong or lanceolate widely diverging lobes of some considerable length. The interior of the pitcher is furnished with hairs pointing downwards; near the upper end they are short and conical, those below are longer. They are of a glandular nature and serve to decompose insects, which are caught in large numbers.

PAPAVERACEÆ.

Benth. et Hook. *Gen. Pl.* i. 49.

Fruit and Seed.—In this Order the carpels are generally connate into an ovoid or oblong one-celled ovary eventually forming a capsule or pod; they are however distinct in Platystemon, and form a two-celled ovary in Glaucium; the ovules are anatropous, ascending or horizontal; the micropyle is inferior;

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[1] Le Maout and Decaisne, p. 213.

and the raphe superior or lateral. The embryo is minute The seeds are globose or reniform, smooth (Sanguinaria, Chelidonium, Hypecoum, Adlumia, &c.) or alveolate (Papaver, Meconopsis, Glaucium, Rœmeria, &c.).

One species of Corydalis presents us with an interesting case of what I have proposed to call Heterocarpism.[1] That is to say, the plant produces two kinds of fruit, one somewhat flattened, short and broad, with rounded angles, the other elongated, hooked, and shaped like a shepherd's crook with a thickened staff. The hook perhaps serves for dispersion. It is possible that the alveolate surface of the seed may serve the same purpose—the depressions imprisoning, as it were, a certain quantity of air, and thus lowering the specific gravity.

In the Poppies the seeds are so situated that they can only leave the capsule if it be swung or jerked by the wind. In the case of trees, even seeds with no special adaptation for dispersion must be often carried by the wind to some distance, and to a certain, though less extent this must hold good even with herbaceous plants. It throws light on the, at first sight, curious fact that in so many plants with small heavy seeds the capsules open not at the bottom, as one might perhaps have been disposed to expect, but at the top. A good illustration is afforded by the well-known case of the common Poppy, in which the upper part of the capsule presents a series of little doors through which, when the plant is swung by the wind, the seeds come out one by one. The little doors are protected from rain by overhanging eaves, and are even said to shut of themselves in wet weather.[2]

Cotyledons.—There are at least four distinct types of cotyledons in the Order, namely, linear, broadly oblong, bifid, and ovate. The first is the most prevalent and characteristic, and may be seen in Platystemon, Papaver, Argemone, Meconopsis, Glaucium, Rœmeria, Hypecoum, and Fumaria. In Papaver villosum var. Heldreichii (fig. 145) they are oblong-linear, obtuse, entire, sessile, one-nerved, and glabrous. Others vary from this in being more slender, and more distinctly linear, and some are narrowed to a petiole as in P. spicatum and occasionally in Meconopsis cambrica. The midrib is not always discernible in fresh specimens. A slight modification occurs in Platystemon californicus (fig. 146), Rœmeria refracta, and Argemone mexicana (fig. 147), where the cotyledons are connate at the base, forming a cup around the plumule. Those of the latter are 16 to 20 mm. long. while in Hypecoum procumbens (fig. 153) they are from 28 to 32 mm., and a similar length in Fumaria.

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[1] *Flowers, Fruits, and Leaves*, 5th edit. p. 90.

[2] *Ibid.* p. 64.

The second type is seen in Bocconia frutescens (fig. 150), a shrubby species in which the carpel contains only one ovule developing into a very large seed for the Order. The cotyledons are oblong, obtuse, tapering to a short, broad petiole, slenderly five-nerved, faintly reticulate, 28 to 36·5 mm. long, and 6·5 to 11 mm. wide.

The bifid cotyledons of Eschscholtzia californica (fig. 152) may be described as an aberrant type, seeing that they are quite entire in E. tenuifolia. Those of the former are linear, slender, 28–30 mm. long, bifid for 18 mm. of their upper portion, with acute segments, slightly dilated and connate at the very base. When full grown they are only about 1 mm. broad below the fissure, and the segments diverge like the prongs of a hay-fork.

A fourth and rather remarkable type is exhibited by Adlumia cirrhosa (fig. 154), Corydalis lutea (fig. 155), and Cysticapnos africana. In Adlumia they are broadly ovate, acute, three- to five-nerved; in Corydalis lutea ovate or lanceolate-elliptic, with the lamina usually sharply deflexed ; and oblong-ovate, and three- to five-nerved in Cysticapnos africana, a Cape species with a bladder-like fruit otherwise similar to the British Corydalis claviculata, but sometimes separated as a distinct genus. All the three plants mentioned have thin membranous delicately-nerved cotyledons with long petioles, thus differing from the species of most other genera in the Order and recalling in their shape that of typical Ranunculaceæ. The peculiar cotyledons of Eschscholtzia californica have already been referred to. If the seed be moderately well buried in the earth, the bent and elongating hypocotyl pulls the cotyledons out of the testa and they soon unfold to the light. Should the seed, however, be lightly buried, it is carried up on the tips of the cotyledons, and the latter soon bulge outwards, balloon-fashion, in their efforts to unfold to the light. As they elongate they become twisted, turning their upper side to the light, until they finally escape from the dried-up testa, and the membranous, skin-like, used-up endosperm ; they often remain twisted for a short time after they are quite free, but finally assume a spreading or ascending position, with the segments about as long as the undivided portion and diverging like the prongs of a hay-fork. The lobes by narrowing the cotyledons would seem to facilitate twisting in order to escape from the seed. E. tenuifolia, with a smaller embryo and narrower but undivided cotyledons, is otherwise similar to E. californica, and germinates in a similar way.

Papaver villosum, *Sil.*, *var.* Heldreichii (fig. 145).

Hypocotyl subterranean or 1–2 mm. exposed.

Cotyledons oblong-linear, obtuse, glabrous.

Leaves simple, radical, alternate, exstipulate, petiolate.

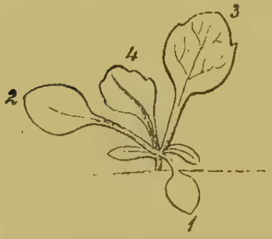

Fig. 145.—*Papaver villosum*, var. *Heldreichii*. Nat. size.

No. 1. Lamina rotund-ovate, obtuse, entire, glabrous ; petiole flattened or slightly channelled above, glabrous, subglaucous.

No. 2. Similar, but larger.

No. 3. Lamina rotund-elliptic, obtuse, with a shallow tooth on each side near the apex, obscurely penninerved and reticulate, glabrous or sparsely pilose.

No. 4. Lamina ovate, obtuse, crenate, cuneate at the base.

The cotyledons in P. caucasicum and P. orientale resemble those of P. villosum. In P. spicatum they are slightly broader in the middle.

Papaver orientale, *L.*, *var.* major.

Primary root nearly perpendicular, unbranched, colourless.

Hypocotyl terete, glabrous, slender, light greyish-green, 1 cm. long, ·75 mm. thick.

Cotyledons sessile, linear-lanceolate, obtuse at apex, entire with distinct midrib, thin, glabrous, light greyish-green, 1 cm. long, 2–2·5 mm. broad.

Stem elongated when about to flower.

Leaves as in preceding, but petiolate or sessile, alternately penninerved, more or less coarsely hairy in the adult state, with a strong midrib, and a yellow or milky-white juice; petioles when present more or less sheathing at the base.

No. 1. Spathulate, obtuse, entire, or with a tooth on one or both sides near the apex, petiolate, glabrous, thin, glaucous.

No. 2. Similar, larger.

No. 3. Subovate, obtuse, with one obtuse serrature on each side.

Papaver spicatum, *Boiss. et Bal.*

Hypocotyl extremely short or subterranean.

Cotyledons linear, tapering to the base, 3–4 mm. long, not very persistent.

Leaves glaucous, petiolate; petioles channelled above, dilated and sheathing at the base; juice milky.

Nos. 1, 2, and sometimes 3. Entire, with an oblong to rotund or ovate-obtuse lamina, and ascending or incurved nerves, glabrous.

No. 4. Rotund, obtuse, crenate-serrate, glabrous.

No. 5. Ovate, obtuse, coarsely and distantly crenate-serrate, sparsely pilose on the upper surface; nerves ascending and incurved.

No. 6. Ovate-oblong, obtuse, coarsely and distantly crenate-serrate, pilose on the upper surface.

Platystemon californicus, *Benth.* (fig. 146).

Primary root tapering downwards with numerous lateral rootlets.

Hypocotyl short, hardly appearing above the soil, stout, obconical.

Cotyledons linear, acute, entire, sessile, glabrous, green, indistinctly one-veined as in the leaves.

Stem with primary internodes undeveloped.

First leaves simple, entire, cauline, alternate, exstipulate, sessile, linear, acute, with

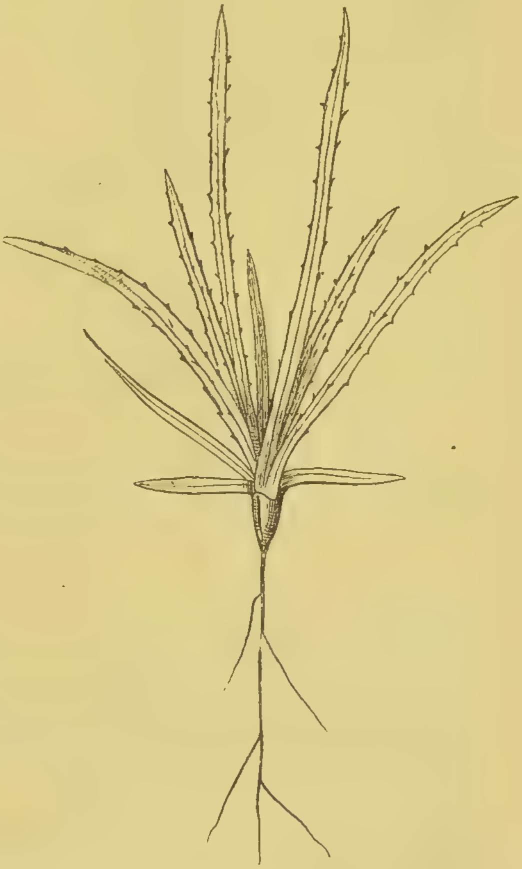

Fig. 146.—*Platystemon californicus.* Nat. size.

scattered coarse hairs on the upper side, and with a spiny margin, except the first one or two, glabrous on the under side, light green, slightly fleshy, one-veined.

The mode of germination closely resembles that of Eschscholtzia tenuifolia.

Argemone mexicana, *L.* (fig. 147).

Primary root tapering, with numerous branching rootlets.

Hypocotyl undeveloped or subterranean and indistinguishable from the root.

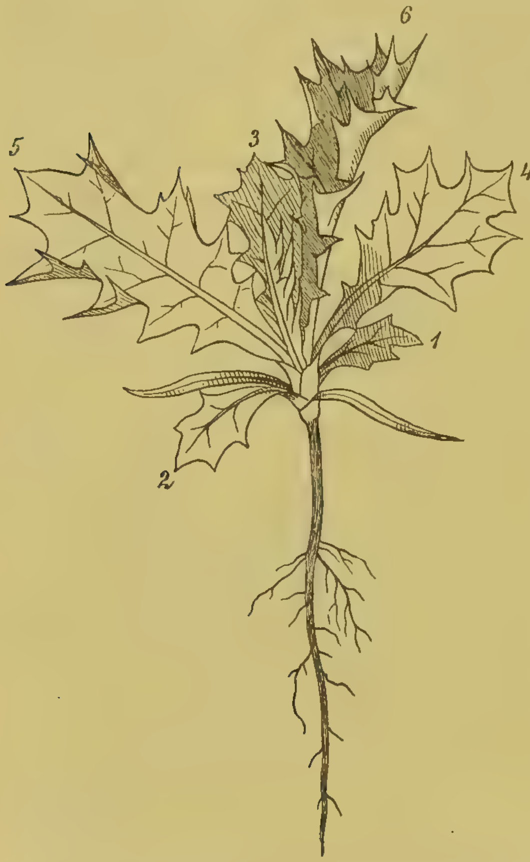

Fig. 147.—*Argemone mexicana.* Nat. size.

Cotyledons linear, entire, acute, dilated and connate at the base, forming a cup round the plumule, glabrous, glaucous on both surfaces, without any discernible venation in the fresh state, 16–20 mm. long.

Stem herbaceous, annual, erect, developed when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, sessile, alternately and ascendingly penninerved, pinnatifid, spiny, with thin prickles on both surfaces, otherwise glabrous, deep glaucous-green above with the midrib and principal nerves splashed with white, much paler and uniformly glaucous beneath, dilated and amplexicaul at the base.

Nos. 1–2. Spathulate-cuneate, acutely dentate-serrate near the apex.

No. 3. Spathulate-cuneate, much larger than the first two, spiny-serrate.

Nos. 4-6. Obovate, pinnatifid or lobulate, undulate at the margin, with the lobes and teeth tipped with spiny bristles.

Meconopsis cambrica, *Vig.* (fig. 148).

Fruit an oblong capsule, tipped with the short, stout, persistent style, one-celled, many-seeded, dehiscing by pores or short valves.

Seed obovoid-reniform, slightly curved, closely reticulated or alveolate, glabrous, dark brown or nearly black; hilum and micropyle contiguous, basal; raphe ventral; chalaza ventral, a little below the apex of the seed and forming a small thickening or crest externally.

Endosperm copious, granular-oily, white.

Embryo small, straight, situated close to the base of the seed, colourless; cotyledons rotund or rotund-ovate, obtuse, entire, plano-convex, ringent, very short, usually two but sometimes three; radicle short, stout, subturbinate, obtuse, about twice as long as the cotyledons and as broad, lying within the endosperm close to the base of the seed.

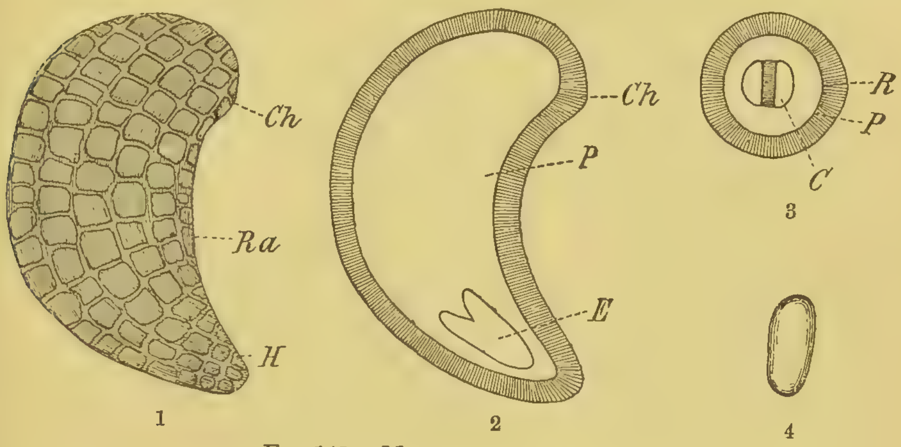

Fig. 148.—*Meconopsis cambrica.*
1, Seed, × 30: *Ch*, chalaza; *Ra*, raphe; *H*, hilum.
2, Longitudinal section of seed, × 30: *E*, embryo; *P*, endosperm; *Ch*, chalaza.
3, Transverse section of seed, × 30: *R*, raphe; *P*, endosperm; *C*, cotyledon.
4, Dorsal aspect of embryo, × 30.

Seedling (fig. 149).

Primary root tapering, colourless, with lateral rootlets.

Hypocotyl fleshy, colourless, 1–4 mm. long.

Cotyledons linear, obtuse, sessile, or frequently narrowed at the base and lengthening into a petiole 5 mm. to 1 cm. long, 1 to 1·5 mm. broad.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, with milky juice; petiole subterete, channelled above, pale green, succulent.

No. 1. Entire, with an ovate, oval, or elliptic lamina.

No. 2. Similar or sometimes slightly trifid.

No. 3. Deeply trifid; lateral lobes oblique; terminal lobe somewhat obovate, obtuse.

No. 4. Tripartite; lateral lobes oblique or subauricled; terminal lobe subelliptic or cuneate, subtrifid.

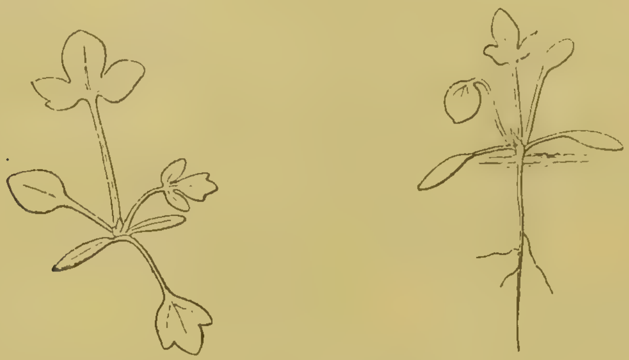

Fig. 149.—*Meconopsis cambrica*. Nat. size.

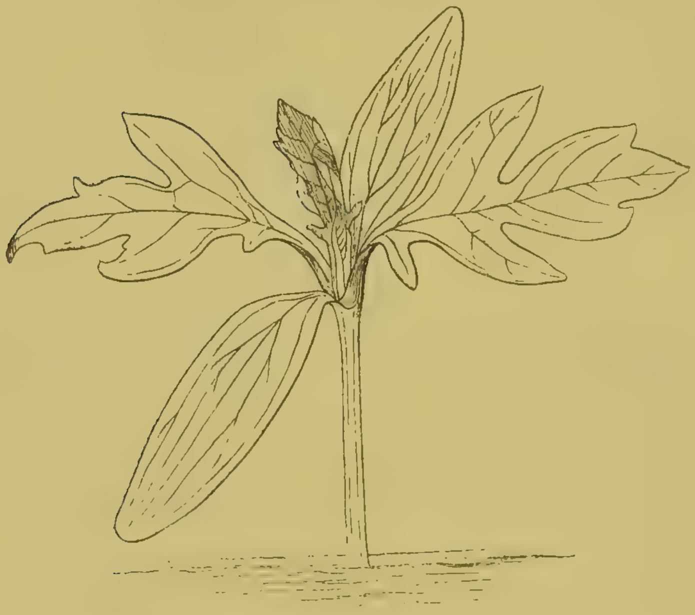

Fig. 150.—*Bocconia frutescens*. Nat. size.

Bocconia frutescens, *L*. (fig. 150).

Hypocotyl erect, terete, tapering upwards from a stout base, glabrous, pale reddish or slightly striate, 2–3 cm. above the soil.

Cotyledons foliaceous, oblong, obtuse, entire, tapered at the base into a short broad petiole, with many slender, longitudinal nerves, best seen by transmitted light, light glaucous-green above, paler beneath with a yellowish hue, slightly reticulate; lamina 26–32 mm. long, 6·5–11 mm. wide; petiole broad, flattened above, convex on the back, 2·25–4·5 mm. long.

Stem erect, terete, ultimately shrubby; primary internodes undeveloped.

Leaves simple, cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved, light glaucous-green above, and obscurely reticulate, paler beneath and distinctly reticulate, glabrous; petiole (in the seedling) semiterete, flattened on the upper side, very slightly winged at the edges, tapering upwards from a broad stout base, rather succulent, with orange-coloured juice.

No. 1. Rhomboid, subacute, tapering to both ends, pinnatifid, with one lobe and a few coarse irregular teeth on each side; lobes or teeth often traversed by two or more longitudinal nerves, and tipped with a glandular mucro.

No. 2. Similar, but larger, and generally more deeply cut.

Glaucium corniculatum, *Curt.*, *var.* rubrum (fig. 151).

Primary root slender, tapering, colourless, almost devoid of lateral rootlets in the early stage, annual or biennial.

Hypocotyl scarcely distinguishable from the root.

Cotyledons linear, slender, soon perishing.

Stem herbaceous and developed only when about to flower.

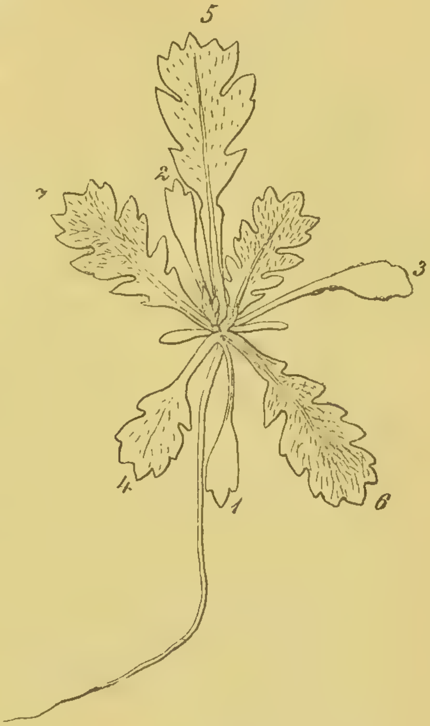

FIG. 151.
Glaucium corniculatum, var. *rubrum*.
Nat. size.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, more or less pinnatifid or pinnatisect and lobed, pilose on both surfaces, especially when young, deeply glaucous above, paler beneath; petioles flattened above, convex below, pilose or woolly at the margins, dilated and amplexicaul at the base.

Nos. 1–2. Spathulate and entire, or tridentate at the apex.

No. 3. Larger, oblong.

No. 4. Oblong, rather coarsely and acutely serrate.

No. 5. Cuneate-oblong, somewhat lobed, retuse and dentate at the apex.

No. 6. Somewhat similar but with more numerous lobes.

No. 7. Oblong-cuneate, retuse and tridentate at apex, pinnatifid and tapering very much to the base; lobes and teeth acute, generally tipped with a bristle.

Glaucium Serpieri, *Heldr.*

Cotyledons lanceolate to oblong, obtuse, entire, petiolate, glabrous, pale glaucous-green, pinnatinerved as in the leaves.

Stem with primary internodes undeveloped.

First leaves as in preceding, cauline and cuneate, tridentate above, serrated, with a few long scattered hairs, glaucous-green, pinnatinerved.

Rœmeria refracta, *DC.*

Hypocotyl terete, its epidermis soon becoming split and completely torn off, 8–13 mm. long.

Cotyledons linear, obtuse, or subacute, entire, connate at the base, glabrous, biconvex, spreading horizontally, 9–11 mm. long.

Stem with its internodes undeveloped in the seedling stage.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, with scattered hairs at least in the young state, brittle, bright green; petiole channelled above, with a prominent ridge beneath, sheathing at the base, narrowly winged as if the leaf were decurrent upon it.

Nos. 1–2. Narrowly spathulate, obtuse, slightly mucronate, tapering gradually into the petiole, entire.

No. 3. Bi- to tri-fid with alternate segments.

Nos. 4–5. Trifid, or 4th to 6th irregularly pinnatifid.

Nos. 6–7. Pinnatifid with alternate segments which are again slightly cut.

Eschscholtzia californica, *Cham.* (fig. 152).

Primary root long, tapering, with short lateral rootlets, yellowish, annual.

Hypocotyl short, tapering downwards, pale and stained with red, glabrous, mostly subterranean, about 4 mm. long.

Cotyledons linear, deeply bifid, segments acute, biconvex, glabrous, glaucous, dilated at the base and perfoliate, 2·8 to 3 cm. long (segments about 1·8 cm. long), 1 mm. broad below the fissure.

Stem herbaceous, annual, developed when about to flower.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, glaucous on both surfaces; petioles shallowly grooved above, slightly carinate on the back, dilated and clasping at the base.

No. 1. Cuneate, tripartite; lateral lobes bifid, terminal trifid; ultimate segments subulate or narrowly oblong, obtuse.

No. 2. Tripartite; lateral lobes cuneate, trifid; terminal one again trilobed with its middle lobe trifid, the others entire.

No. 3. Bi-ternatisect; ultimate segments lanceolate, obtuse, or subacute.

Nos. 4–6. Bi- to tri-ternatisect; ultimate segments as in No. 3.

Ultimate leaves radical, deltoid in outline, tri-ternatisect, with oblanceolate or linear-oblanceolate, subacute segments, tipped with orange-red, petiolate; cauline exactly similar or smaller and with shorter petioles.

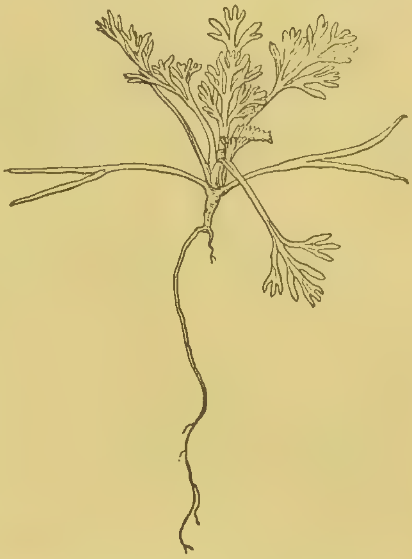
FIG. 152.—*Eschscholtzia californica.* Nat. size.

Eschscholtzia tenuifolia, *Benth.*

Primary root as in preceding, but slender, colourless.

Hypocotyl slender, erect, terete, glabrous, pale glaucous-green, or colourless towards the base, 6·5–18 mm. long.

Cotyledons slender, linear, attenuated, obtuse, shallowly grooved above, convex on the back, glabrous, glaucous, slightly broader above the middle representing a lamina, ascending or arching outwards above the middle, 14–30 mm. long, ·5–1 mm. wide.

Stem short, erect, developed when about to flower, leafy; primary internodes undeveloped.

Leaves cauline, entire at first, ultimately pinnatisect, with a vein running through each segment, but not discernible in the fresh state, shallowly grooved above; petioles rounded on the back or subcarinate, grooved above; otherwise as in preceding species.

No. 1. Linear, obtuse, slender, entire, or rarely (? accidental) showing a lateral segment, similar to itself but shorter.

No. 2. Linear, slender, entire, similar to the first.

Hypecoum procumbens, *L.*

Fruit a dry, indehiscent, linear, straight or curved horn-like pod, segmented and forming a more or less conspicuous transverse ridge between each seed, each of the latter being contained in a separate locellus by a transverse development of cellular tissue. During germination the pod or its segments separate slightly along both sutures to allow the seedling to get out.

Seed lenticular, somewhat flattened laterally but convex, rounded on all the edges except the ventral, which is straight, deep brown or almost black, very minutely and inconspicuously glandular or reticulate.

Germination. When the seeds swell, the pod bursts along both sutures and the radicle protrudes, fixes itself deeply in the soil, and together with the lengthening and straightening hypocotyl assists the cotyledons in making their exit from the seed and pod.

The cotyledons are linear, acute, tapering upwards, and very slender, semiterete at the base, and more or less completely terete upwards, 14–20 mm. long. By their growth in length during germination their exit from the seed and pod is materially assisted.

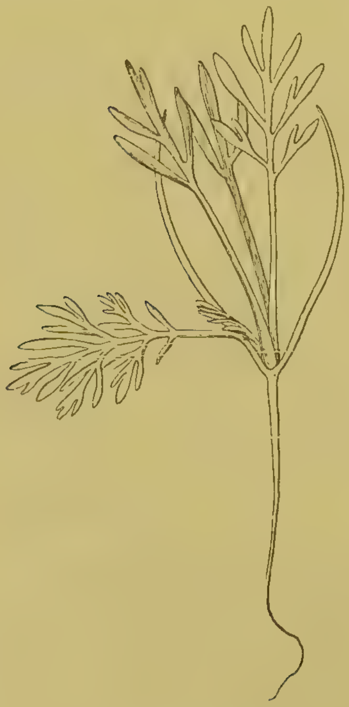

Fig. 153.—*Hypecoum procumbens.* Nat. size.

Seedling (fig. 153).

Primary root slender, tapering, with a few lateral rootlets, annual.

Hypocotyl terete, tapering indistinguishably into the primary root, glabrous, pale green, 3–5 mm. above the soil.

Cotyledons subulate, much attenuated, slender, tapering upwards from a dilated connate base, sessile, grooved from the base for some distance upwards, pale glaucous-green, fading to a yellowish green when old, glabrous, entire, 2·8–3·2 cm. long, about 1 mm. wide near the base.

Stem annual, developing when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, pinnately multisect, with the venation ramifying accordingly, and sending a nerve into every branch or segment, glabrous, glaucous, with slender segments, covered with minute glands; petioles semiterete, flattened or convex above but channelled towards the dilated and amplexicaul base, glaucous at first, then a pale green.

No. 1. Pinnatisect, with three oblanceolate-linear, obtuse segments.

No. 2. Similar or with four to five segments, that is, one or two on each side of the leaf.

No. 3. Pinnatisect or slightly bi-pinnatisect, with the secondary divisions on the anterior side of the primary ones; segments slender, lanceolate-linear.

No. 4. Bi-pinnatisect, with lanceolate-linear, obtuse or rather acute segments.

Adlumia cirrhosa, *Raf.* (fig. 154).

Primary root tapering, brittle, succulent, yellowish, with a few lateral rootlets.

Hypocotyl erect, terete, succulent, glabrous, reddish, 7–16 mm. long.

Cotyledons petiolate, glabrous, pale green; petioles horizontal, slender, slightly channelled on the upper side, subdilated and connate at the base, 16 mm. long; lamina ovate, acute, faintly five-nerved, pendent, recurved, 6 mm. long, 4·25 mm. broad.

Stem developed the second year to 12 feet or more, slender, climbing by means of tendrils.

Leaves simple, ternatisect, radical and cauline (the second year), alternate, exstipulate, petiolate, glabrous, pale green above, nearly glaucous beneath, thin and delicate, marked with fine, more or less forking, ascending or suberect veins; petioles succulent, brittle, channelled on the upper side, much dilated at the base and obtusely subcarinate.

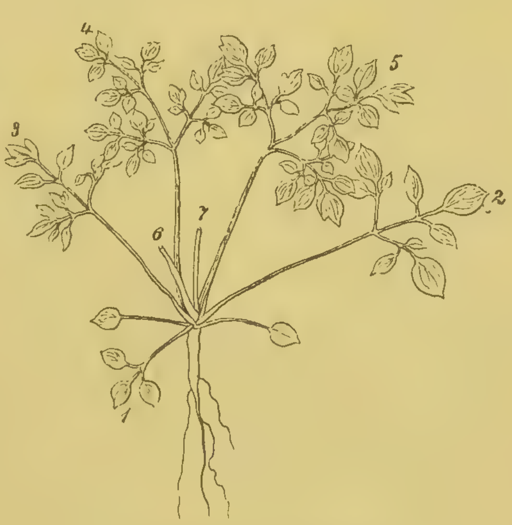

FIG. 154.—*Adlumia cirrhosa.* Half nat. size.

Nos. 1 and 2. Ternate; lateral segments ovate, cuspidate; terminal one elliptic, cuspidate. No. 2 in robust specimens biternate.

No. 3. Biternate or in robust seedlings triternate.

No. 4. Triternate.

No. 5. Triternate, with the terminal lobe of the primary divisions bi- or trifid.

No. 6. Triternate with many of the larger lobes more or less cut.

No. 7. Triternate, and much cut. (Nos. 6 and 7 in fig. 154 have been cut off.)

Ultimate leaves large, triternately multisect; ultimate segments ovate, cuspidate; terminal ones obovate, cuspidate.

Corydalis lutea, *DC.* (fig. 155).

Hypocotyl erect, terete, glabrous, reddish, about 1 cm. long.

Cotyledons ovate or lanceolate-elliptic, acute, petiolate, glabrous, pale green, often mottled with red; lamina sharply decurved, 6.5 mm. long, 3 mm. broad; petiole terete, glabrous, subdilated at the base, 7·5 mm. long.

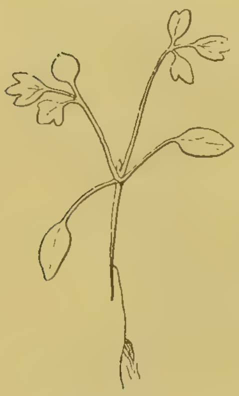

FIG. 155.—*Corydalis lutea.* Nat. size

Stem herbaceous, short, stout, producing flowering branches.

Leaves simple, ultimately bi-ternatisect, radical and cauline, alternate, exstipulate, petiolate, glabrous, pale glaucous-green; petioles obtusely trigonous, or flattened above and subcarinate beneath, especially towards the base, dilated and semi-amplexicaul at the base, glabrous.

No. 1. Ternatisect; terminal segment rotund, trinerved, trifid; lateral segments rotund, entire or tridentate.

No. 2. Similar.

Ultimate leaves bi- to tri-ternatisect; terminal segment of each primary division cuneate, trifid, with obtuse, mucronate teeth; other segments oval or elliptic, entire or bi- to tri-dentate or -fid, obtuse and mucronate at the tips.

In C. nobilis the cotyledons are oval, oblong, obtuse, and minutely emarginate.

Fumaria Vaillantii, *Lois.*

Hypocotyl erect, striated, glabrous, 10 mm. long, reddish.

Cotyledons linear, acute, tapering to the base, entire, light green, glabrous, indistinctly one-veined.

Stem with primary internodes scarcely developed.

Leaves multisect, petiolate, glabrous; 1st leaf less divided than succeeding leaves, cauline, alternate; segments mostly trilobed, the lobes being again bi- to tri-lobed; lobes linear-lanceolate or linear-oblong, acute.

Cysticapnos africana, *Gaertn.*

Hypocotyl filiform, 3 or 4 cm. long, ·75 mm. thick, green, with reddish striæ.

Cotyledons petiolate, glabrous, blade 1 cm. long, 4 mm. broad, ovate-lanceolate, trinerved, the lateral nerves sending branches towards the margin only, entire, thin, glaucous ; petiole 5 or 6 mm. long, ·5 mm. thick.

Leaves.—No. 1. Including slender petiole, 1·5 cm. long, 6–8 mm. broad, trifid, glabrous, thin, glaucous.

No. 2. Trisect, basal lobes or sections bifid.

Ultimate leaves simple, multisect, radical and cauline, alternate, exstipulate, petiolate, glabrous, glaucous, membranous ; petioles more or less dilated and sheathing at the base.

CRUCIFERÆ.

Benth. et Hook. *Gen. Pl.* i. 57.

Fruit and Seed.—In this great Order the ovary is composed of two connate carpels, very rarely of three to four, as in Tetrapoma, Holargidium (a monotypic Siberian genus now merged in Draba), and sometimes Brassica and Nasturtium ; the ovules are numerous, or few or solitary, pendulous or horizontal, very rarely basilar (Clypeola) or apical (Isatis), campylotropous or half-anatropous, with the raphe ventral and the micropyle superior. The fruit (a pod) is short or elongated, usually two-celled.

The seeds are oblong, subglobose, or flattened and margined, or winged, and exalbuminous (except in some species of Isatis), the embryo occupying the whole seed.

The embryo is rarely straight (Leavenworthia), generally more or less curved. The cotyledons are sometimes linear and coiled on themselves or folded transversely (Diplocolobeæ), but generally broad, sometimes folded in two along their length and embracing the radicle, sometimes incumbent to the radicle (fig. 162), sometimes accumbent (fig. 158).

Diptychocarpus has two kinds of pods, the upper ones, like those of a Matthiola, compressed, with winged seeds, the lower ones rounded, indehiscent, and transversely multilocular.

Geococcus buries its pods in the ground.

The Order presents a vast amount of variation in the form of the fruit, seed, and embryo. For purposes of classification of the genera, it is above all things necessary to consider the form and characters of the fruit; though these do not invariably indicate the true lines of natural affinity, as for instance in the case of Raphanus and others amongst the Raphaneæ, and Crambe, Rapistrum, and others amongst the Cakilineæ, which are obviously closely allied to the Brassiceæ.

The Order may be conveniently divided into five groups according to the form and folding of the embryo, excluding some aberrant species which may be dealt with separately. It must be admitted, however, that the form of the embryo alone will not in all cases indicate the true lines of natural affinity, although it offers a convenient means of grouping the seeds. The latter are exceedingly variable in mere outline, being flat, compressed, ovoid, oblong, linear, globular, or winged; but none of these characters are so constant as are the various forms of the embryo. The latter may be briefly described as having the cotyledons accumbent, incumbent, conduplicate, transversely biplicate, and circinately convolute, while in the aberrant forms the cotyledons are sometimes deeply divided.

Taking the Wallflower (Cheiranthus Cheiri) (fig. 158) to represent embryos having accumbent cotyledons, we find that the seed is oblong-oval, much compressed laterally, with the edges produced all round into a thin membranous wing. The embryo is flat with ovate, obtuse, entire cotyledons, and the terete, slightly curved radicle is laid against the edges of the closely adpressed seed-leaves. If the double seed-coat is removed from one side of the seed, the edges of the petioles are seen, in some cases at least, as if the embryo had originated with the cotyledons in the narrow plane of the seed and the seed-leaves had afterwards become twisted round to accommodate themselves in the broader plane during the process of growth.

Embryos with accumbent cotyledons prevail throughout the Arabideæ, Alyssineæ, Thlaspideæ, and in five genera at least of the Isatideæ, in Cakile amongst the Cakilineæ, and in Chorispora amongst the Raphaneæ.

Other genera agreeing with Cheiranthus in the flattened and winged characters of the seeds are Matthiola, Diptychocarpus, Cithareloma, Arabis, Farsetia, Vesicaria, Lunaria, and others. Seeds in several other genera have a broad or narrow margin as in Streptanthus and Lonchophora, but can hardly be called winged, while some of the species of Parrya have broadly winged and others entirely wingless seeds.

Cheiranthus pygmæus has accumbent or incumbent, straight or convolute cotyledons even in the same pod.

Wingless seeds whose embryos have accumbent cotyledons are represented by Nasturtium, Cardamine, Aubrietia, Barbarea, Alyssum, Draba, Cochlearia, Biscutella, Thlaspi, Iberis, Cakile, and Chorispora. The seeds of the genera just mentioned further differ amongst themselves in being ovoid or turgid as in Nasturtium and Cochlearia, somewhat compressed in Barbarea, and very much so, or almost flat, in Draba, Alyssum, Biscutella, and Iberis.

Besides Cheiranthus pygmæus above mentioned, there are several other cases where the embryo is slightly but only occasionally modified so that the normally accumbent cotyledons become obliquely so or slightly incumbent in species of Barbarea, Draba bruniæfolia, D. boreale, D. frigida, Cochlearia arctica, C. glauciphylla, Cakile maritima, and possibly some others where the character may be even more marked. Lepidium virginicum also belongs to the group with accumbent cotyledons. It differs markedly from the rest of its congeners, all of which have incumbent cotyledons. Decaptera, consisting of a single species from Chili, has also accumbent cotyledons, although it belongs to the Lepidineæ like the last.

Incumbent cotyledons are characteristic of Sisymbrieæ, Camelineæ, and Lepidineæ, three tribes of considerable size, while many instances also occur in the Isatideæ. The cotyledons are likewise incumbent in the Brassiceæ primarily as well as in genera of the Isatideæ, Cakilineæ, and Raphaneæ, with longitudinally plicate or conduplicate cotyledons; but it is convenient to group these types by themselves on account of the distinctly more complicated character of the embryo. The seeds in this group are oblong, oval, ovoid, or variously angled; and there is a general absence of the flattened or winged character typical of the first group. In many instances there is a distinct ridge along one side of the seed, generally, if not always, on the dorsal aspect, and in this the radicle is accommodated, the ridge itself finding room in a corresponding concave or grooved line along the middle of the two valves of the siliqua. Should the seeds be comparatively large, they are arranged in one line along the middle of the two cavities of the ovary. The various species of Erysimum and Sisymbrium show this well. The carpels of Lepidium are laterally flattened and keeled on the back; each cavity contains one, rarely two seeds; and these are suspended from the apex of the placenta, and trigonous with the thinnest edge lying in the cavity of the keel as in L. sativum and L. graminifolium (fig. 171); in other cases they are laterally flattened but not trigonous. The seeds of Æthionema heterocarpum are covered with mucilaginous tubercles, and the testa of Lepidium is also mucilaginous when moist, which may assist in retaining it in the soil, while the embryo escapes during germination.

Several curious modifications occur in this group. The oblong seeds of Isatis tinctoria (fig. 174) are solitary in each fruit, which is indehiscent, and furnished with a curious corky wing along the back of each carpel. The cotyledons are concave longitudinally and slightly embrace the stout radicle. Hesperis matronalis (fig. 162) is unsymmetrical, one of the cotyledons being considerably smaller than the other. The seeds of Sisymbrium officinale are variously shaped and angled, while the radicle in most cases lies obliquely across the back of the cotyledons. The same may be said of Ochthodium ægyptiacum (fig. 175), which has a woody, curiously tuberculated, indehiscent fruit. Tetrapoma, a Siberian genus, containing only one species, has a one- or four-celled ovary, according as the partitions are developed to the centre or not, while there are four split or double placentas with the seeds arranged in eight rows.

Conduplicate cotyledons are typically characteristic of all the eleven genera classed in the tribe Brassiceæ; but they also occur in Tetrapterygium, Calepina, Boleum, and Zilla amongst the Isatideæ, and several other genera in this tribe show an approach to the same arrangement by the cotyledons being longitudinally concave, slightly folded or longitudinally plicate, as in Myagrum, Schimpera, and Texiera. All the seven genera of the Isatideæ just mentioned have short one- to two-celled fruits with as many seeds, thick and lignified pericarps, the thicker parts of which become corky while the fruit is indehiscent. As far as the fruit is concerned they seem reduced forms of Cruciferæ adapted for countries with a dry climate, or for dry, rocky, or chalky places. They may also be allied to the Brassiceæ, just as Crambe, Muricaria, Rapistrum, Enarthrocarpus, Hemicrambe, Erucaria, Guiraoa, Fortuynia, Physorhynchus, and Morisia amongst the Cakilineæ, undoubtedly are. Raphanus and Raffenaldia amongst the Raphaneæ also approximate to Brassica in the form of the embryo, but differ in having fruits which break up into lomenta or indehiscent pieces each containing one seed. The cotyledons of Anchonium and Sterigma, also belonging to the Raphaneæ, have incumbent and flat or concave cotyledons, showing a tendency to become conduplicate. The shape of seeds having conduplicate cotyledons varies considerably, but taking Brassica, Diplotaxis, Eruca, Succovia, Crambe, and Raphanus as types, the seeds are globose or ovoid. This may be seen by reference to Brassica oleracea or B. nigra. The relation of the seed to the peculiar form of the cotyledon has been already described (*ante*, p. 43).

Raphanus sativus (fig. 62) and R. maritimus agree in most essential particulars with Brassica, except that the seeds are generally larger, and enclosed singly in indehiscent segments of the pod. A rather differently shaped seed occurs in Zilla myagroides. The fruit is globular, indehiscent, thick, lignified, and surrounded with another thick, ‘suberous’ or corky layer—the exocarp. Two oval and slightly compressed or lenticular seeds occupy a central position, side by side but in separate cells. The corky exocarp and woody endocarp would indicate adaptation to a dry climate, and we find that the four known species are natives of North Africa, Arabia, and Persia.

Another modification occurs in Orychophragmus, which has an oblong, subtriquetrous seed. A third and more remarkable type is presented by Euzomodendron, Savignya, Moricandia and Henophyton, the seeds of which are compressed, the testa forming a line round the margin, or a narrow or even broad wing similar to what occurs in Cheiranthus, Matthiola, Lunaria, or Vesicaria with accumbent cotyledons.

Transversely biplicate cotyledons occur in a few genera, of which the principal is Heliophila, containing about fifty or sixty species of annual or perennial herbs with a few shrubs. The fruits vary considerably in being oblong, oval, linear-lanceolate or linear and moniliform, and on this account the genus has been split up into some half-a-dozen by different authors. The seeds also vary in being oblong, oval, or almost perfectly orbicular, much compressed or quite flattened laterally, and wingless as in Heliophila pilosa, var. incisa (fig. 166), or broadly winged in H. crithmifolia, H. callosa, and others. There is a more or less deep notch at the hilum in winged seeds. The cotyledons are incumbent, transversely biplicate, and placed in the narrow plane of the seeds with their backs to the placenta. They are consequently very narrow, their width being dependent on the width or size of the seed and the mutual pressure of the folds on the edges of one another. Their thickness depends upon the thickness of the seed, as they are adpressed face to face with their edges to the flattened sides of the latter. Heliophila belongs to the tribe Sisymbrieæ. Chamira, belonging to the same group, agrees with Heliophila in its seeds and embryo. Palmstruckia and Cycloptychis amongst the Isatideæ have also transversely biplicate cotyledons, and Carponema, classed under the Raphaneæ, is remarkable in having oblong, terete seeds and cotyledons like those of Heliophila, to which it is closely allied. See Sond. 'Revis. Helioph.' 3, t. xvii. Senebiera may be included in this group.

Spirally convolute cotyledons occur in the four known species of Bunias. The fruit is short, ovoid, tetragonous, lignified, one- to two-celled with a somewhat compressed seed in each cell, the appearance being due to the shrinking of the testa to accommodate itself to the spirally coiled embryo. The cotyledons are incumbent with their edges to the sides of the seed, oblong, obtuse, entire, forming 1½–2 complete coils with their tips in the centre of the helix. The stout cylindrical radicle extends beyond the cotyledons, occupying the upper and pointed end of the seed, beneath and close to the persistent base of the style.

Only two strikingly aberrant forms in the Order have come under my observation. These are Schizopetalon belonging to the Sisymbrieæ, and Lepidium sativum amongst the Lepidineæ. Five species of Schizopetalon are recorded, all from Chili. The cotyledons are straight and entire in some of them, but S. Walkeri (fig. 160) has incumbent, deeply bifid, or more often bipartite, spirally convolute, and contorted cotyledons; the slender, linear segments being regularly coiled, but generally more or less interlacing with one another. The species might be grouped with Bunias, but for the deeply divided and contorted cotyledons. Some botanical authorities have described it as having four cotyledons, but they are mostly united in pairs at the base, and sometimes for a considerable part of their length. The embryo by becoming spirally convolute adapts itself to the interior of the small globular seed, which it completely occupies. The radicle is comparatively large and longer than the cotyledons. Lepidium sativum (fig. 171) is another aberrant form. It has been already described (*ante*, p. 52).

Cotyledons.—Notwithstanding the diversity of the seeds and fruits in this Order, the cotyledons may be roughly grouped into a few leading types, viz., broad and entire, broad and emarginate, linear, oblong or spathulate, and divided.

The first type is represented by Matthiola incana (fig. 156) and Cheiranthus Cheiri (fig. 159), but is not confined to seeds having accumbent cotyledons. Instances of broad, rotund, ovate, oval or elliptic, and entire cotyledons may be found in nearly all the tribes into which the Order is divided. In the case of accumbent cotyledons they are situated in the broader plane of the seed, so that their shape and size is easily accounted for, especially in flattened seeds; but in many cases breadth is attained by a vigorous growth of the cotyledons subsequent to germination. The following are instances of broad cotyledons occurring in species scattered throughout the order, namely: Matthiola incana, Alyssum maritimum, Hesperis nivea, Conringia perfoliata, Camelina sativa, Biscutella didyma, Lepidium graminifolium, L. spinosum, Iberis corifolia, and Chorispora tenella. A slight modification is met with in Æthionema gracile and Iberis Lagascana, which have unsymmetrical cotyledons, slightly oblique at the base, and very much so in I. pectinata. It is probable that other instances of the kind occur in Iberis and indeed in other genera. The inequality at the base is due to the fact that part of the space in the seed is occupied by the radicle and petioles, which lie along one edge of the accumbent cotyledons.

Emarginate cotyledons are almost as widely distributed throughout the Order as those that are entire. The notch or sinus is due to two totally different causes. The first type is not owing to any peculiar conformation or structure of the seed, the cotyledons being, as far as could be seen before germination, entire. The notch in the seed-leaves is therefore due to the subsequent greater growth of the sides as compared with the organic apex. Emarginate cotyledons occur in Nasturtium sylvestre, Arabis Turczaninowii, Cardamine hirsuta, C. græca, Lunaria biennis, Cochlearia glastifolia, Sisymbrium officinale, Bivonæa Saviana, and others. The entire and emarginate state is shown in the figure of Sisymbrium officinale (fig. 163).

The second type of emarginate cotyledons occurs among the Brassiceæ and others, in which the cotyledons are conduplicate, as has been already mentioned in the Introduction (see *ante*, p. 31). Brassica oleracea (fig. 169) may be taken as a type. The cotyledons are emarginate with a broad and moderately deep sinus, broader than long, unequal in size, trinerved at the base with alternate veins upward, and the midrib forking below the apex; the side lobes are rounded and ascending. The inequality is due to the arrangement in the seed, one cotyledon folding over and completely embracing the other, which is necessarily smaller, being in the centre of the sphere. The petiole of the larger, occupying the outside of the curve, must also be the longer. The base of the sinus is really the organic apex of the cotyledons, and the ascending lobes are due to lateral development. When the cotyledons are folded longitudinally the two ascending edges of the lateral lobes are pressed against and conform to the interior of the globular seed, while the organic apex is also pressed against the testa and its further development consequently stopped. Growth then proceeds in a lateral direction as long as there is any unoccupied space, thus determining the peculiar form of the cotyledons as seen in germination.

All the species of Brassica observed conform closely to the above type, as do also Moricandia hesperidifolia, Carrichtera Vellæ, Succovia balearica, Raphanus sativus, R. maritimus &c. Zilla myagroides (fig. 177) seems to differ slightly, but the seeds from which the seedlings were raised were museum specimens, probably old, and the cotyledons, which were slightly eroded in the sinus, might have been deformed. More decided departures from the type are exhibited in several other genera. Diplotaxis erucoides has broadly oblong, obtuse, emarginate cotyledons; in Moricandia arvensis they are obovate or cuneate, and slightly emarginate; while in Orychophragmus sonchifolius they are broadly oblong-ovate and emarginate, the smaller one being more evidently cuneate at the base than the other. All have the cotyledons unequal in size like those of Brassica, and, what is more unusual, they are indistinctly veined in Diplotaxis erucoides, Moricandia arvensis, and Orychophragmus sonchifolius.

In the case of Hesperis matronalis the cotyledons are not only unequal in length, but vary also in size and shape. By reference to the illustration (fig. 162) it will be seen that the unsymmetrical condition already prevails in the seed before germination. The seed is oblong and terete with the incumbent cotyledons slightly concave longitudinally, and the thin radicle lies in the groove. One cotyledon is nearly as thick as the other plus the radicle. After germination the cotyledons of most seedlings belonging to this species are obovate, emarginate, the two measuring 25 and 27·5 mm. in length respectively, while cases occur in which they are rotund, emarginate, broader and shorter, measuring 17·5 and 15 mm. respectively, the latter being about 1 mm. wider than those of the first mentioned.

In several of the Sisymbrieæ and Lepidineæ the cotyledons are minute; this seems to be due partly to the small size of the seeds, partly to a limited range of growth. The latter case might arise from the embryo in the seed containing a relatively small amount of reserve-material, or more probably from the plumule developing early and diverting the energies of the plant away from the cotyledons. The latter are shortly oblong, obtuse, with a long petiole in Sisymbrium runcinatum (fig. 164), and S. Sophia, and linear-spathulate with rather long petioles in Capsella Bursa-pastoris (fig. 170) and Senebiera didyma. The cotyledons of all the four species, but especially of Senebiera, recall those of Papaver in their small size and narrowness.

Linear cotyledons occur in Heliophila amplexicaulis (fig. 167), H. crithmifolia, and probably in all the rest of the genus. This type however is quite unusual in the Cruciferæ. The former of the two species has linear, obtuse, entire, one-nerved cotyledons, tapering insensibly or gradually into a short petiole and measuring from 20–25 mm. in length. Those of H. crithmifolia are linear, acute, entire, subterete, distinctly channelled all along the upper surface, sessile, slightly narrowed to the base, thinly pilose, or pubescent, 20–38 mm. long, and becoming disarticulated from the stem at an early age.

It is probable that the seedlings of Palmstruckia, Cycloptychis, Carponema, and Chamira have also linear cotyledons. Spirorhynchus has narrowly linear, incumbent cotyledons. Those of Menonvillea trifida are incumbent, long, narrowly linear, acute, sessile, and glabrous; in the early stages they are circinately coiled.

In all these cases the narrowness of the cotyledons is due to the shape of the seed, the position of the embryo with relation to the broad and narrow planes of the seed, and the peculiar folding of the embryo.

The spathulate type of cotyledons seems to be largely due to growth subsequent to germination, as we meet with it in a few more or less widely distinct genera having differently shaped seeds and fruits, and widely diverse embryos. Bunias orientalis (fig. 176) may be given as an instance of this type. The cotyledons are spirally coiled in the seed, with their apices in the centre of the coil, where they are distinctly narrowed, but after attaining their full size they are spathulate, obtuse, entire or slightly emarginate, unequal in length, tapering to a short, petiole-like, shortly connate base, and showing a few alternate, ascending veins on each side of a strong midrib. The average length of three of the longer cotyledons measured was 42 mm., and of three of the shorter ones 33 mm. The seed-leaves of Cakile maritima are linear-spathulate, obtuse, entire, unequal, sessile, tapering to the base, one-nerved, subfleshy. The inclination to assume this shape no doubt originates in the seed, which is oblong, slightly notched at the base, and 3–3·5 mm. in length. The upper division of the two-seeded fruit is the longer and contains the larger seed, which is laterally compressed. The cotyledons are accumbent, sometimes oblique, and lying on the edge of one cotyledon only, which would tend to make one of them narrower than the other, but the inequality in length is more difficult to account for. The cotyledons of C. americana both before and after germination are proportionally broader than those of C. maritima. The seeds of the former are however longer, measuring 5–6 mm., and the cotyledons after germination are spathulate, obtuse, sessile, but tapering to the base, and much more unequal than those of C. maritima.

The divided cotyledons of Schizopetalon Walkeri and Lepidium sativum have been already described. One advantage of this form is perhaps that it enables each of the four segments to emerge from the testa independently of the others. The cotyledons of Schizopetalon Walkeri (fig. 160) are generally divided almost to the base, although there are cases where they are merely forked like those of Eschscholtzia californica in the closely allied Order Papaveraceæ. The cotyledons become curved and then coiled at a very early age of the embryo, which develops very rapidly, and they are ultimately not merely coiled, but frequently interlaced. The whole embryo is extremely delicate or fragile in its earliest stages, and the extreme slenderness of the cotyledons compared with the stout radicle facilitates their being coiled in order to accommodate themselves closely to the interior of the small round seed without waste of space. After germination and when fully grown the cotyledons of Lepidium sativum are so deeply tripartite, each segment being narrowed to the base, that they appear as if digitately compound. The probable origin of their present form has already been suggested, *ante* p. 52.

The dispersal of the seeds is in many cases aided by the presence of wings; in some by the agency of animals; in others they are thrown to a greater or less distance by the plant itself.

In the latter cases the walls, when the pod is ripe, are in a state of tension. The seeds are loosely attached to the central piece by short stalks. When the proper moment has arrived, the outer walls are kept in place by a delicate membrane, only just strong enough to resist the tension. The least touch, for instance, a puff of wind blowing the plant against a neighbour, detaches the outer wall, which suddenly rolls itself up, generally with such force as to fly from the plant, thus jerking the seeds to a distance of several feet.

Matthiola incana, *R. Br.* (fig. 156).

Primary root long, tapering downwards, with a few short lateral rootlets.

Hypocotyl short, erect, terete, tapering insensibly into the root, glabrous, pale green, covered with small crystalline elevations, 8–12 mm. long.

Cotyledons broadly oblong-oval, obtuse and rounded at the end, entire, petiolate, glabrous, light opaque green, with a scarcely visible midrib, but no other discernible venation in the fresh state; lamina 9–11 mm. long, 7–9 mm. wide; petiole grooved above, convex on the back, glabrous with a line of small crystalline elevations on the under side, dilated and slightly connate at the base, 7–9 mm. long.

Stem erect, terete, herbaceous, biennial, densely covered with much branched and radiating stellate hairs; 1st internode 1–1·5 mm. long; 2nd undeveloped; 3rd 1·5–2·5 mm. long.

Leaves simple, entire, cauline, alternate (first two opposite), exstipulate, petiolate, with a hardly discernible venation, except in very young leaves, where the nerves are alternate, ascending and incurved, uniting with one another within the margin; densely covered on both surfaces with a much-branched stellate pubescence or tomentum and becoming hoary, especially in dry places; petioles tapering upwards, from a stout, broadish, semiamplexicaul base, semiterete, slightly convex or flattened on the upper side, hoary with a stellate tomentum like the leaves.

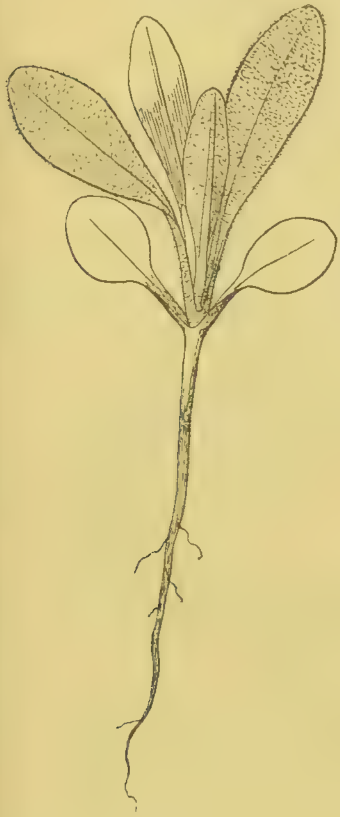

FIG. 156.—*Matthiola incana.* Nat. size.

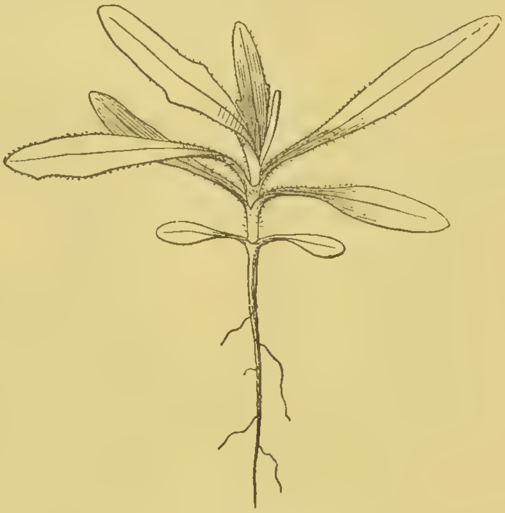

FIG. 157.—*Matthiola bicornis.* Nat. size.

Nos. 1 and 2. Oblanceolate, tapering to the petiole, obtuse at the apex and rounded.

Nos. 3 and 4. Similar or somewhat narrower.

Matthiola bicornis, *DC.* (fig. 157).

Primary root as in M. incana.

Hypocotyl very short, tapering into the primary root, colourless, slightly glandular-pubescent, 1·5–3 mm. long.

Cotyledons narrowly oblong-spathulate, tapering into the petiole, or slightly glandular-pubescent at the margins, otherwise as in M. incana; lamina 5–6 mm. long, 2–2·25 mm. wide; petiole flattened above, convex on the back. glabrous or slightly glandular-pubescent, slightly connate at the base, 3·5–5 mm. long.

Stem herbaceous, annual, terete, erect, more or less glandular-hairy and densely stellato-tomentose; 1st internode 3–4·5 mm. long; 2nd undeveloped; 3rd 1·5–2 mm. long.

Leaves narrower than in M. incana.

Nos. 1 and 2. Opposite, oblong, obtuse, entire.

No. 3. Linear-oblong, obtuse, entire or with one or two very short obtuse teeth.

Nos. 4–6. Linear, obtuse, with one or two blunt deltoid or sub-triangular teeth on each side.

Nasturtium sylvestre, *R. Br.*

Primary root tapering downwards, provided with lateral rootlets.

Hypocotyl short, erect, hardly appearing above the surface of the soil, obconical.

Cotyledons subrotund or oblong, obtuse, emarginate, subfleshy, glabrous, green, indistinctly one-veined, petiolate; petiole rather long, channelled on the upper side.

Stem with primary internodes undeveloped.

First leaves simple, coarsely crenate, radical, alternate, oblong, obtuse, petiolate, exstipulate, hairy, especially on the upper side, green, distinctly pinnatinerved; petioles rather long, deeply channelled on the upper surface.

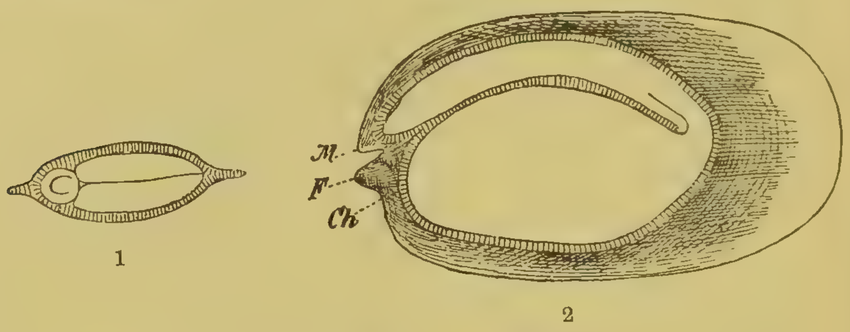

Fig. 158.—*Cheiranthus Cheiri.*

1, Transverse section through middle of seed, × 11.
2, Vertical section of seed, × 11: *M*, micropyle; *F*, funiculus; *Ch*, chalaza.

Cheiranthus Cheiri, *L.* (fig. 158).

Fruit a siliqua, linear, compressed dorsally, two-edged or sub-tetragonal, two-celled, dehiscing by two valves from base to apex: placentas many-seeded, parietal; septum thin, membranous, formed by extension of the placentas.

Seed oblong-oval, much compressed laterally, with the edges produced all round into a thin membranous wing; seed-coat double, outer (testa) membranous, pale yellow, glabrous; inner (tegmen) paler and thinner; hilum basal, at one end of the seed; raphe none; micropyle basal, close to the hilum and superior to it.

Endosperm absent.

Embryo large, curved, occupying the whole interior of the seed, pale yellow; cotyledons oblong-oval, obtuse, entire, flat, closely adpressed face to face, petiolate; radicle slender, cylindrical, suddenly tapered to a subacute point, curved, nearly or quite as long as the accumbent cotyledons; petioles short, slightly twisted to allow the edges of the cotyledons to be applied to the radicle. If it were not for the petioles the cotyledons would evidently be incumbent, as happens in some species of Cheiranthus, with their backs instead of their edges to the placenta; under existing conditions the backs of the petioles are to the placenta.

Seedling (fig. 159).

Hypocotyl herbaceous, erect, terete, glabrous, or hairy towards the top; hairs adpressed, forked at right angles and thus appearing as if fixed by the middle; 12–27 mm. long.

Cotyledons broadly ovate, retuse, entire or very minutely or slightly emarginate, suddenly tapering into the petiole, glabrous or slightly hairy here and there on the upper surface; petiole with forked hairs as described above; lamina 10–13 mm. long, 6·2–10 mm. wide; petiole 8·5–11·5 mm. long.

Stem herbaceous, erect, terete, covered with hairs as described above, ultimately shrubby below; internodes short but variable; 1st 3–7 mm. long; 2nd often very short or scarcely developed, bringing the first two leaves nearly opposite; 3rd more elongated.

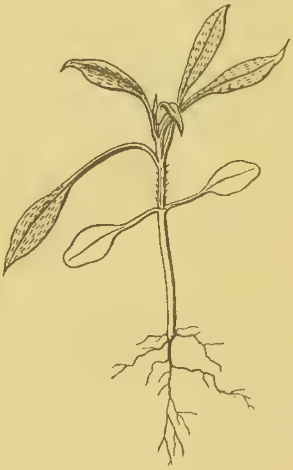

Fig. 159.—*Cheiranthus Cheiri* (wild specimen). Two-thirds nat. size.

Leaves simple, cauline, alternate, exstipulate, petiolate, covered on both sides, especially in a young state, with forked, peltate hairs rarely branching stellately, and closely adpressed, with the branches lying in the same plane; petioles convex on the back, grooved on the upper face and pubescent like the leaves.

Nos. 1–6. Lanceolate-elliptic, acute, petiolate, obscurely reticulate, often minutely and sparingly denticulate.

Ultimate leaves narrowly lanceolate, cuspidately acute, narrowed to a rather broad petiole, subcarinate on the back, with a prominent midrib and alternate lateral nerves ascending along the leaf for some considerable distance and uniting, each with the one next above it; white or hoary, especially beneath, with a closely adpressed pubescence of the characteristic forked hairs.

Arabis Turczaninowii, *Ledeb.*

Primary root tapering downwards with fibrous lateral rootlets.

Hypocotyl erect, terete, glabrous, almost colourless, 5–10 mm. long.

Cotyledons oval-oblong, emarginate, petiolate, fleshy, green, glabrous; no venation apparent.

Stem: primary internodes undeveloped.

Leaves simple, entire, cauline, alternate, lanceolate, acute, exstipulate, petiolate, finely pubescent, ciliate, pinnatinerved.

Cardamine Impatiens, *L.*

Fruit a siliqua, linear, compressed dorsally, many-seeded, with the seeds in one row, dehiscing elastically with some force from the base upwards by two valves and scattering the seeds; septum thin, membranous.

Seed oblong, obtuse at each end, much compressed dorsally, pale yellow, smooth; testa thin, subtransparent; hilum basal, brown; micropyle close to the hilum.

Endosperm absent.

Embryo much curved or doubled upon itself, occupying the whole seed, colourless or pale yellow; cotyledons oblong, obtuse, entire, plano-convex, accumbent, very shortly petiolate; radicle slender, terete, suddenly tapered to an obtuse point which is slightly curved round the apical ends of the cotyledons, equal to or slightly longer than these.

Cardamine græca, *L.*

Primary root tapering downwards, colourless, with numerous lateral rootlets.

Hypocotyl terete, rather succulent, flexuose, glabrous, purplish, 2·3 cm. long, 1·5 mm. thick.

Cotyledons foliaceous, glabrous, petiolate; petiole subterete, channelled above, purplish, 1·45 cm. long; lamina rotund-oblong, emarginate, dull green, rather fleshy, 1·2 cm. long, 1 cm. broad.

Stem herbaceous.

Leaves radical, simple, pinnatisect, alternate, exstipulate, petiolate, minutely ciliate at the margins of the lobes when young, glabrescent, dull green above, paler beneath; petioles subterete, channelled above, dilated at the base, dull purplish-green, dotted with pale markings, glabrous.

No. 1. Ternately pinnatisect; lobes rotund-subcuneate, shortly trifid or crenate; lobes most frequently emarginate and mucronate,

No. 2. Pinnatisect; lobes 5, similar to No. 1.

Nos. 3 and 4. Pinnatisect; lobes 7, in three opposite pairs and an odd terminal one.

Cardamine hirsuta, *L.*

Hypocotyl short, terete, glabrous, passing indistinguishably into the root.

Cotyledons differing from those of C. græca in being rotund, about 3·5 mm. in diameter; petiole 4 mm. long.

Stem herbaceous, annual, developed when about to flower, angled, glabrous or slightly hairy; basal internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, more or less hairy on both sides, bright green above, paler beneath; petioles subterete, channelled on the upper side.

Nos. 1 and 2. Reniform, subemarginate, obscurely crenate.

No. 3. Reniform with one small lateral lobe, obscurely crenate.

No. 4. Deeply trilobed; lateral lobes obovate; terminal lobe much larger, rounded.

No. 5. Similar, larger.

No. 6. Lyrate-pinnatisect with a terminal, large, rotund lobe and two pairs of much smaller lateral ones.

No. 7. Lyrate-pinnatisect; terminal lobe rotund, minutely emarginate, trinerved; lateral lobes rotund-obovate, minutely emarginate.

No. 8. Pinnatisect; three terminal segments obovate, minutely emarginate, otherwise like No. 7.

Cauline leaves on robust plants lyrate, pinnatisect; segments broad, reniform, or subrotund, angled with excurrent teeth.

On small starved specimens, the lower or all the cauline leaves are lyrate, pinnatisect, with obovate or spathulate segments; the upper ones have linear-oblong segments.

Lunaria biennis, *Mœnch.*

Hypocotyl erect, terete, glabrous, 5–6 cm. long, stained with red.

Cotyledons large, broadly oblong, obtuse, slightly emarginate, petiolate, glabrous, green, rather distinctly pinnatinerved; petioles from 2·5 cm. long, reddish, channelled on the upper side.

Stem erect, quadrangular, rather flattened, pubescent, herbaceous; 1st internode 3–4 mm. long.

Ricotia Lunaria, *DC.*

Hypocotyl terete, striate, rather slender, 5–7 cm. long.

Cotyledons suborbicular, broad, emarginate or bifid, rather coarsely reticulate, unequal, especially as regards the length of the petioles; lamina of two good-sized specimens 2·5 and 2·7 cm. long, 2·6 and 2·7 cm. wide respectively; petioles shallowly grooved above, 2·9 and 3·5 cm. long.

Stem finely pubescent with the first internode shortly elongated or not.

Leaves simple, mostly cauline, alternate, exstipulate, petiolate, usually much cut.

Nos. 1 and 2. Pinnatisect, with five more or less toothed segments.

Nos. 3–6. Pinnatisect or (mostly) bi-pinnatisect.

Alyssum maritimum, *Lam.*

Hypocotyl erect, terete, glabrous, 8–9 mm. long, purplish.

Cotyledons oval, obtuse, entire, petiolate, glabrous, green, sub-fleshy, indistinctly one-veined; petioles rather short, shallowly channelled on the upper face.

Stem erect, terete, herbaceous; primary internodes but slightly developed.

First leaves simple, entire, cauline, alternate (first pair opposite), linear-oblong or lanceolate, obtuse, exstipulate, petiolate, covered with minute silky hairs, green, pinnatinerved.

Cochlearia glastifolia, *L.*

Primary root forming a long tap-root, with numerous lateral rootlets.

Hypocotyl very short, terete, glabrous, purple, 2–3 mm. long.

Cotyledons suborbicular, emarginate, glandular in the notch, slightly oblique at the apex, glabrous, petiolate, opaque above, obscurely trinerved beneath; lamina 5–9 mm. long, 6·5–9 mm. wide; petiole semiterete, flattened above, widened and slightly connate at the base, 4·5–6·5 mm. long, purple.

Stem with the internodes undeveloped.

Leaves simple, radical, alternate, exstipulate, petiolate, glabrous, with the petiole, midrib, and ascending, incurved, and reticulate venation, purple beneath; petiole semiterete, channelled above, winged in the younger leaves of the seedling from the blade being decurrent upon them.

Nos. 1 and 2. Suborbicular or obovate, slightly emarginate, with a gland in the notch.

Nos. 3 and 4. Obovate, emarginate, glandular in the notch.

Nos. 5 and 6. Larger and obovate, or tending to be spathulate, and decurrent upon the petiole.

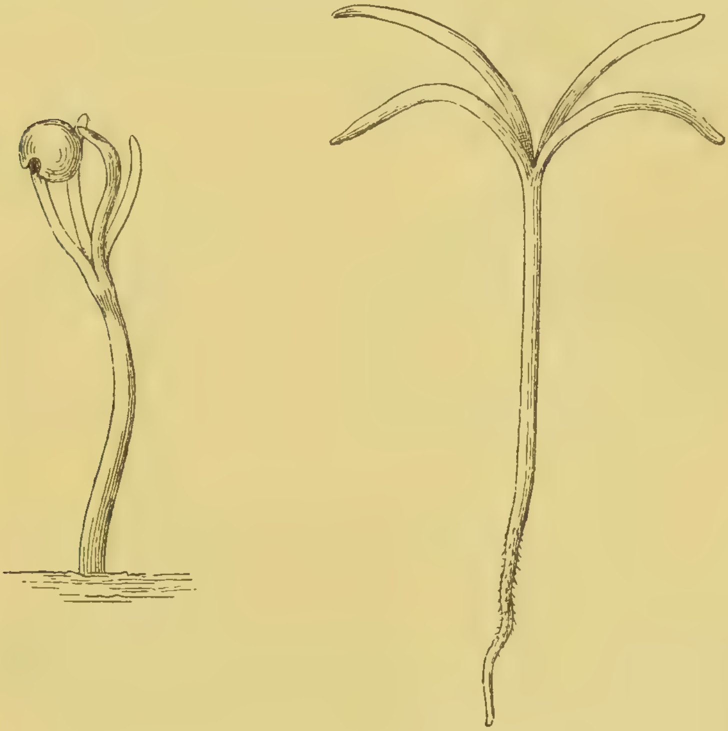

Fig. 160.—*Schizopetalon Walkeri*, × 2½. (Early stages in growth of seedling.)

Cochlearia arctica, *Schlecht.*

Hypocotyl erect, terete, glabrous, 1–2 cm. long, light green or colourless.

Cotyledons obovate or subrotund, fleshy, unequal, emarginate, with very long petioles, glabrous, bright green, very indistinctly trinerved.

Stem as in the preceding species.

First leaves with long petioles, subrotund, emarginate, obtuse, cordate at the base, bright green, glabrous, distinctly pinnatinerved.

Schizopetalon Walkeri, *Sims.*

Fruit a silicula, narrowly linear, subcompressed, two-celled, many-seeded, dehiscent.

Seeds parietal, in one row, globose, very small, pale yellow, often with a bluish tinge; micropyle and hilum punctiform, ventral, contiguous; raphe ventral.

Endosperm absent.

Embryo comparatively large, spirally convolute, and conforming to the interior of the seed; cotyledons bipartite with narrowly linear or acicular segments, sometimes exhibiting regular spiral coils, but often irregular and more or less irregularly twisted amongst each other, one or two lobes inside the others; radicle comparatively large, and rather longer than the incumbent cotyledons, which have their backs to the placenta.

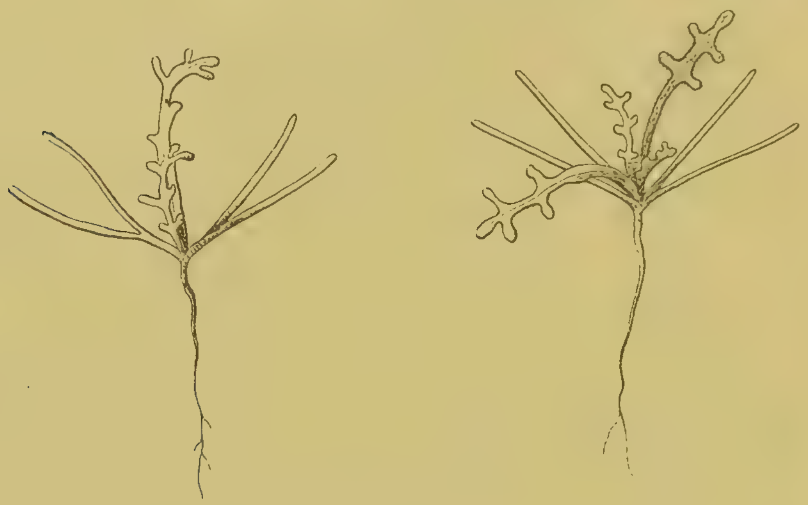

Fig. 161.—*Schizopetalon Walkeri.* Nat. size.

Seedling (figs. 160, 161).

Primary root slender, tapering, with very few lateral rootlets in the young state.

Hypocotyl tapering indistinguishably into the root.

Cotyledons split almost to the very base, but sometimes, although rarely, united (as in accompanying sketch) for 4·75 mm. at the base; segments filiform, blunt, glabrous, deep green, rather fleshy, 2 cm. long.

Stem annual, developed when about to flower.

Leaves simple, pinnatifid, radical and cauline, alternate, exstipulate, petiolate, stellately pubescent, rather fleshy, opaque green; petioles semiterete, flattened above or shallowly grooved, stellately pubescent.

Nos. 1 and 2. Oblong in outline, pinnatifid; segments five or six, short, oblong, obtuse, or the terminal one spathulate.

No. 3. Oblong in outline, pinnatifid with about seven segments.

Hesperis matronalis, *Lam.* (fig. 162).

Siliqua linear, tetragonous, subtorulose, glabrous, dehiscing throughout its length by two valves, many-seeded with the seeds in one row, and partly separated by a contraction of the fruit; valves trinerved, with the middle nerve strongest.

Seed oblong, subterete in transverse section, tapering slightly to the apex, where the testa is drawn out into a short margin, glabrous, brown; hilum and micropyle basal, contiguous at the upper end of the seed; chalaza thickened, deep brown, immediately beneath the hilum; raphe none.

Endosperm absent.

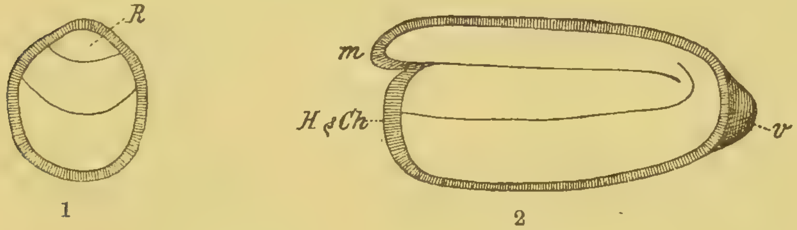

FIG. 162.—*Hesperis matronalis*, × 10.

1, Transverse section of seed: *R*, radicle.

2, Longitudinal section of seed: *m*, micropyle; *H* & *Ch*, hilum and chalaza; *v*, vacant space in testa.

Embryo doubled upon itself, comparatively large, and occupying the whole interior of the seed, pale yellow; cotyledons incumbent, linear-oblong, obtuse, entire, somewhat grooved or concave longitudinally, shortly petiolate, about equal in length to the interior of the seed, the two frequently of unequal thickness; petioles apparently facilitating the necessary curvature of the embryo; radicle dorsal, obtusely trigonous, about equal in length to the seed, partly accommodated by the concavity of the cotyledons, and partly by extension of the testa along the dorsal aspect.

Seedling.

Hypocotyl erect, terete, glabrous, tinged with purple, 3–5 mm. above the soil.

Cotyledons very variable in shape and size, often unequal, rotund, emarginate, suddenly tapering to the base, or obovate, emarginate, and gradually tapering to the base, glabrous, light green, alternately and ascendingly penninerved and reticulate, thick and opaque, showing the venation only by transmitted light, petiolate; lamina 10–15 mm. long, 10–12 mm. wide (the rotund forms being the wider); petiole flattened above, convex beneath, dilated and connate at the base.

Inequality of cotyledons.—In plant No. 1, 2·5 and 2·75 cm.; in plant No. 2, 1·75 and 1·5 cm. long.

Stem herbaceous, developed when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, alternately, ascendingly incurvinerved, the reticulate venation seen best by transmitted light, rather coarsely hairy all over, deep or light green; petioles channelled above, convex beneath, hairy, stout, tapering upwards from a broad, slightly clasping base; hairs hyaline, simple or forked, or with a small lateral branch.

Nos. 1–3. Varying from oblong to oval, or broadly ovate, rounded and obtuse at the apex, suddenly tapered at the base, slightly dentate, with the teeth tipped with a yellowish glandular mucro; the nerves incurved and uniting with one another within the margin, forming a series of large reticulations.

Hesperis nivea, *Baumg.*

Primary root tapering downwards, with many lateral rootlets.

Hypocotyl terete or tapering downwards, 5–6 mm. long, greenish above, colourless below the soil.

Cotyledons oval-oblong, obtuse, entire, indistinctly one-veined; petioles broad, channelled on the upper surface.

Stem as in H. matronalis.

First leaves entire or slightly serrate; first two broadly subrotund, obtuse, the rest broadly oblong, all covered with rather stiff hairs, indistinctly pinnatinerved; petioles broad, much longer than the leaves, hairy, rather deeply channelled on the upper surface.

Hesperis bituminosa, *Savi.*

Hypocotyl 2–3 mm. above the soil.

Cotyledons roundly obovate, more or less unequal, measuring 11 and 13·5 mm. respectively, and in another case 12 and 13 mm., glabrous except the slightly channelled petioles, blunt or very shallowly emarginate.

First leaves ovate, obtuse, slightly dentate, but sometimes more elongated and spathulate, hairy.

Sisymbrium officinale, *L.*

Siliqua linear or subterete, somewhat compressed, short, erect, and closely adpressed to the stem; the numerous seeds mostly in one row.

Seed oblong, short, blunt at each end, where it is very frequently obliquely compressed or truncate, smooth and minutely reticulated with small superficial areas that swell up in water, yellow ; hilum basal, overlying the chalaza and contiguous to the micropyle ; raphe none.

Endosperm absent.

Embryo doubled upon itself, comparatively large, and occupying the whole interior of the seed, pale yellow ; cotyledons oval-oblong, obtuse, entire, shortly petiolate, showing a midrib and a few short, alternate, ascending lateral nerves, obliquely incumbent, nearly as long as the interior of the seed ; radicle terete or more or less obtusely angled, traversing one edge of the dorsal aspect of the seed, and then suddenly bent towards the micropyle at one corner of the oblique, rhombus-shaped dorsal aspect, longer than the seed by its traversing one end as well as the dorsal face of the embryo.

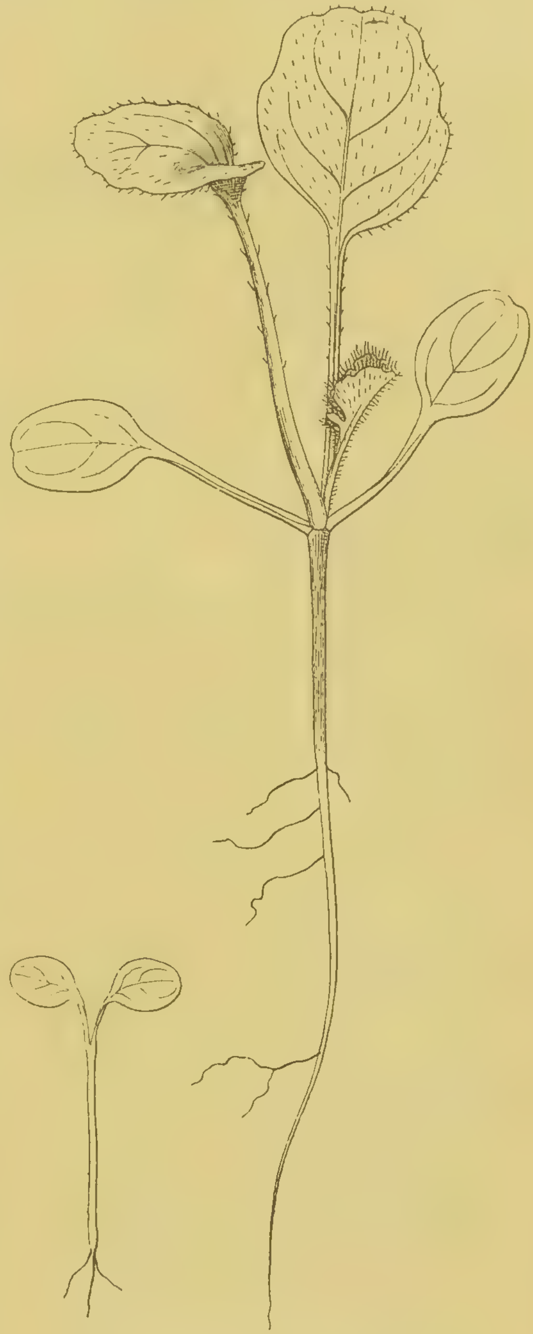

FIG. 163.—*Sisymbrium officinale*, × 2.

Seedling (fig. 163).

Primary root long, tapering, fibrous, annual.

Hypocotyl erect, terete, pale green, or sometimes stained with red, becoming thicker upwards, with a few scattered adpressed hairs ; 8–18 mm. long.

Cotyledons oval, obtuse and rounded at the apex after germination, but becoming emarginate and more elongated at the base by subsequent growth, petiolate, glabrous, with the exception of a few scattered hairs on the petiole, light green above, paler beneath, trinerved at the base, with two other lateral nerves arising from the midrib below the middle of the lamina, describing a curve round an oval space and again uniting with the midrib close to the apical notch; lamina 6–8 mm. long, 4–5·5 mm. wide; petiole slightly channelled above, convex on the back, 7·5–9 mm. long.

A few terminal pores or *water-stomata* are found at the apex of the midrib.

Stem annual, and developed when about to flower; primary internodes undeveloped.

Leaves simple, radical (ultimately cauline), exstipulate, petiolate, coarsely hairy, alternately and ascendingly penninerved, ultimately runcinately pinnatifid and pinnatisect; petioles semiterete, channelled above, dilated and clasping at the base, more or less hairy.

No. 1. Rotund, obtuse, obscurely dentate or crenate, slightly cuneate at the base.

No. 2. Similar but more deeply dentate-crenate and often lobulate at the base.

No. 3. Runcinately pinnatisect with three to five lobes; lateral lobes small, oblong, obtuse, entire or dentate; terminal lobe much the largest, rotund, coarsely and deeply dentate with glandular mucronate teeth.

Sisymbrium runcinatum, *Lag.* (fig. 164).

Root and *hypocotyl* as in preceding species.

Cotyledons small, glabrous; lamina oblong, obtuse, 4 mm. long, 2 mm. broad; petiole 3·5 mm. long.

Stem as in Hesperis matronalis.

Leaves hairy, especially when young and on the petioles, ultimately glabrescent; petioles flattened above, convex beneath, slightly dilated at the base.

No. 1. Small, broadly ovate, obtuse, almost or quite entire.

No. 2. Oblong, sublobulate; lobes rounded.

Nos. 3 and 4. Similar but larger.

No. 5. Oblong, pinnatifid; terminal lobe triangular-hastate, with a very obtuse apex and side lobes.

No. 6. Pinnatifid with obtuse lobes; terminal one triangular obtuse.

Nos. 7–10. Runcinate, pinnatifid; lateral lobes broadly ovate, or triangular obtuse, or rounded at the end, alternate, spreading at right angles to the rachis or slightly decurved, frequently tipped with a bristle when young; terminal lobe much the largest, triangular, obtuse.

Sisymbrium Sophia, *L.* (fig. 165).

Root and *hypocotyl* as in preceding species.

Cotyledons oblong, obtuse; petiole flattened above, and more or less covered with stellate, stalked hairs, convex beneath.

Leaves more or less lobed or pinnatisect, covered on all parts with stalked and stellately branching hairs; petiole flattened above, convex beneath.

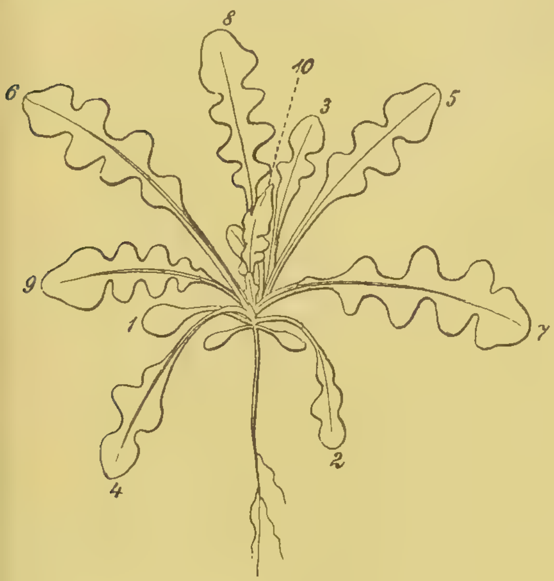

FIG. 164.—*Sisymbrium runcinatum.* Nat. size.

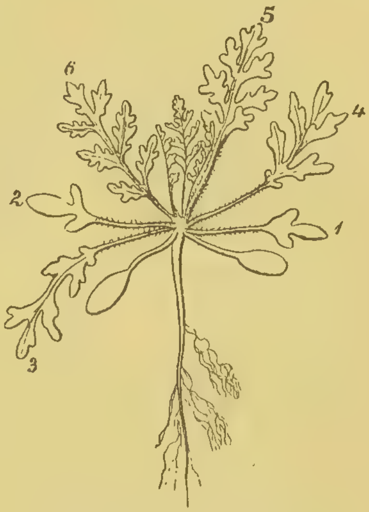

FIG. 165.—*Sisymbrium Sophia.* Nat. size.

No. 1. Lamina ovate, obtuse, trilobed, cuneate at the base; middle lobe longest.

No. 2. Similar; middle lobe of the lamina a little longer.

No. 3. Lamina oblong, pinnatipartite; lobes slightly toothed, alternate.

No. 4. Lamina oblong, pinnatisect; lobes toothed.

Nos. 5 and 6. Lamina oblong, pinnatisect; lobes pinnatifid, alternate.

Conringia perfoliata, *Link.*

Hypocotyl tapering downwards, glabrous, green or colourless, 3–4 mm. long.

Cotyledons rotund-ovate, obtuse, entire, rather fleshy, petiolate, glabrous, green, indistinctly one-veined; petioles broad, flat, not quite as long as the lamina.

Stem with primary internodes undeveloped.

First leaves simple, entire, radical, alternate, broadly obovate-oblong, obtuse, glaucous-green, glabrous, pinnatinerved, exstipulate, petiolate; petiole short, broad, slightly channelled on the upper surface.

Heliophila pilosa, *Lam.*, *var.* γ, incisa *DC.* (fig. 166).

Siliqua linear, many-seeded.

Seed variable in outline, oblong, or more or less perfectly orbicular, much compressed laterally, with a small notch at the base, and a narrow marginal wing or altogether wingless, pale or deep brown, glabrous; both testa and tegmen membranous; hilum, micropyle, and chalaza contiguous, basal; raphe none.

Embryo filling the entire seed, pale yellow or colourless, much curved and folded; cotyledons incumbent, biplicate, each traversing the length of the seed about three times, that is, first lying towards the base of the seed, then folded back towards its apex, and finally folded again towards the base, and each occupying half the thickness of the seed collaterally, linear, obtuse, entire, square or variously angled; the several folds and the radicle occupy the width of the seed; radicle terete, obtuse, occupying the length of the seed and one end, lying against the back of the third and apical fold of the cotyledons.

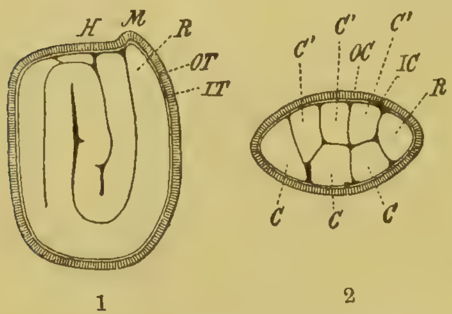

Fig. 166.—*Heliophila pilosa incisa*, ×12.

1, Longitudinal section of seed: *H*, hilum; *M*, micropyle; *R*, radicle; *OT*, testa; *I T*, tegmen.

2, Transverse section of another seed: *C C C*, parts of one cotyledon; *C' C' C'*, parts of the other cotyledon; *R*, radicle; *O C*, testa; *I C*, tegmen.

The 'Flora Capensis' does not say whether the siliquas of the genus Heliophila are dorsally or laterally compressed, but a figure of Heliophila trifida, *Thunbg.*, in the 'Botanical Register,' 64, shows a dehiscing siliqua which is dorsally compressed.

Heliophila crithmifolia, *Willd.*

Seed orbicular, flattened or much compressed laterally, testa brown, shrunk when dry so as to show the form of the embryo; hilum forming a rather deep notch.

Cotyledons and *radicle* arranged as in H. pilosa.

Primary root annual, tapering, but little branched.

Hypocotyl erect, terete, pubescent, 2–2·5 cm. long.

Cotyledons linear, acute, subterete, distinctly channelled along the whole upper surface, very thinly pilose or pubescent, sessile, slightly narrowed to the base, 2–3·8 cm. long, deciduous, becoming disarticulated from the stem.

Stem annual, erect, terete, pubescent; 1st internode 9–10 mm. long.

Leaves simple, cauline, alternate (1st pair almost opposite), exstipulate, petiolate, thinly pubescent, finely divided or cut, with linear subterete acute segments, all channelled on the upper surface; petiole semiterete, channelled above, articulated with the stem.

Nos. 1 and 2. Almost opposite, pinnatisect, with one or two alternate segments on each side.

Succeeding leaves with more numerous, opposite or alternate segments.

Plant running to seed very rapidly, even in the seedling pots before being planted out.

Heliophila amplexicaulis, *L.* (fig. 167).

Primary root long, tapering downwards, with short lateral rootlets.

Hypocotyl glabrous, purple, dotted with green, 8–10 mm. long.

Cotyledons linear obtuse, entire, tapering insensibly into the petiole, glabrous, erect or ascending, green or more or less tinged with purple; a midrib is present, but no other venation is discernible; 2–2·5 cm. long, 1–1·5 mm. wide.

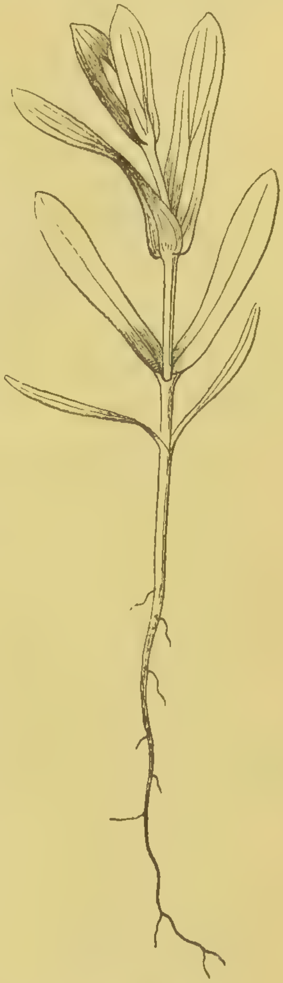

FIG. 167.—*Heliophila amplexicaulis.* Nat. size.

Stem erect, terete, glabrous, green or becoming purple and dotted with green, annual; 1st internode 5–10 mm. long, 2nd 6–13 mm.

Leaves opposite (at least on the lower part of the plant up to and including the fifth pair), sessile, with numerous, alternate, ascending, slender nerves, proceeding from the midrib at a very acute angle, incurved, and uniting with one another at their apices, while a number run close to the apex of the leaf, and curving inwards unite with the midrib; glabrous, glaucous-green on both surfaces, amplexicaul at the base.

1st and 2nd pairs linear oblong, cuspidate, somewhat constricted above a broad, amplexicaul base, and again dilated above the middle, entire.

3rd pair oblong, cuspidate, amplexicaul, less conspicuously constricted above the base or not at all, entire.

Camelina sativa, *Crantz.*

Hypocotyl short, erect, terete, glabrous, 3–5 mm. long, light green or colourless.

Cotyledons oval-oblong, obtuse, entire, glabrous, rather fleshy, shortly petiolate, light green, with no apparent venation.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, obovate-oblong, obtuse, crenate, exstipulate, petiolate, hairy, green, pinnatinerved; the first leaf is often entire; petioles rather long, hairy, channelled on the upper side.

Diplotaxis erucoides, *DC.*

Hypocotyl short, terete, hardly appearing above the surface of the soil.

Cotyledons oblong, obtuse, emarginate, petiolate, rather fleshy, glabrous, green, indistinctly one-veined.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, obovate-oblong, obtuse, exstipulate, petiolate, hairy, green, pinnatinerved; the first leaf is entire, the second leaf crenate or almost lobed.

Brassica nigra, *Boiss.*

Siliqua sessile, terete, or subtetragonal, beaked, many-seeded; beak often one-seeded and indehiscent.

Seed globose or oblong-globose, often appearing angled from the unequal shrinking of embryo and testa in malformed or immature seeds, small; testa deep brown or almost black when the seed is perfectly matured; hilum small, occupying one end of the seed when the latter is oblong-globose; chalaza contiguous to the hilum, and forming a dark-coloured spot; raphe none; micropyle close to the hilum.

Embryo large and filling the whole interior of the seed, doubled upon itself twice, pale yellow or in immature seeds deep green; the incumbent cotyledons conduplicate, that is folded upon themselves longitudinally, and grasping but not surrounding the radicle with their edges; radicle oblong, suddenly tapering to an obtuse point, shorter than the cotyledons.

Seedling (fig. 168).

Hypocotyl erect, terete, glabrous, pale green, 1·5–3·8 cm. long.

Cotyledons broadly cuneate, bifid, broader than long, unequal in size, with two strong, alternate nerves, and one or two short ones, entering each lobe, glabrous, light green, paler beneath, petiolate; average of three larger laminæ 12·8 mm. long, 14·9 mm. wide; of three smaller laminæ 11·75 mm. long, 13·8 mm. wide; petiole shallowly channelled above, convex on the back, slightly connate at the base, glabrous, pale green, unequal in length, the longer one bearing the larger lamina; average length of three of the longer ones 13·75 mm., of three of the shorter ones 12·58 mm.

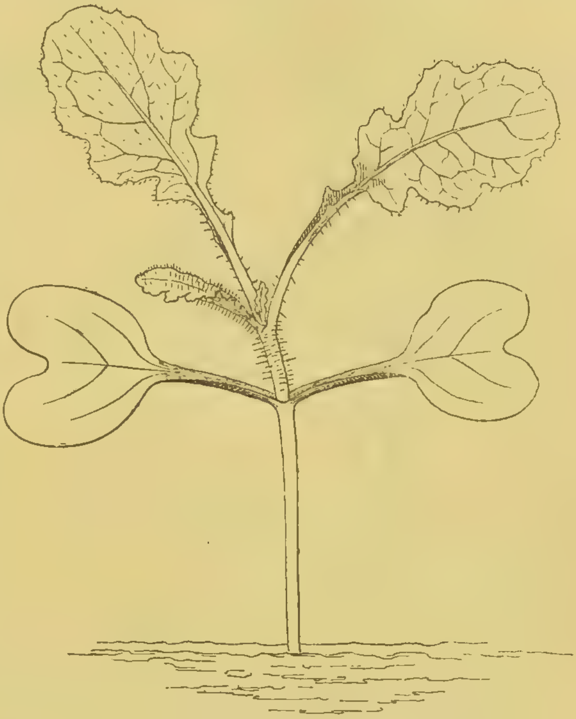

FIG. 168.—*Brassica nigra.* Nat. size.

The reason for this peculiar form has been suggested above, pages 31 and 43.

Stem erect, terete, coarsely hairy with bulbous-rooted hairs; striated longitudinally or shallowly ridged and furrowed, herbaceous, annual, pale green; 1st internode 3·5–12·5 mm. long; 2nd to 4th or more undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, alternately penninerved, with zigzag nerves more or less incurved, and entering straight into the marginal teeth or lobes or giving off branches into them, hairy on both surfaces, reticulate, light green above with sunk nerves, paler beneath with prominent nerves, more or less decurrent on the petiole; petiole semiterete, channelled above, with rather acute edges, coarsely hairy, somewhat dilated at the base.

Nos. 1 and 2. Opposite, or slightly alternate by the development of the second internode, oblong-obovate, with a broad, obtuse point, more or less lobulate and dentate, lobes deltoid, obtuse, decurrent on the petiole.

No. 3. Oblong, more or less distinctly lyrate-pinnatifid.

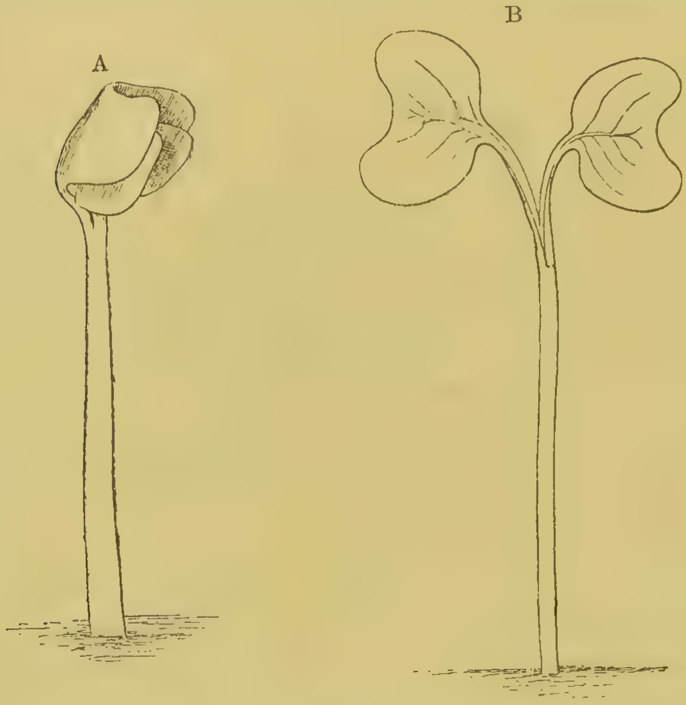

Fig. 169.—*Brassica oleracea.*
A × 4, B × 3.

Brassica campestris, *L.*, *var.* Rapa. White Globe Turnip.

Cotyledons transversely oblong, otherwise as in B. nigra. Individuals vary greatly in size, and length of petioles.

Brassica oleracea, *L.* (fig. 169).

Cotyledons broader than long, bifid with a broad sinus, lobes ascending, rounded.

Average size of three larger laminæ 6·5 mm. long, 10·08 mm. wide.

Average size of three smaller laminæ 6 mm. long, 8·8 mm. wide.

Average length of three longer petioles 8·58 mm.
" " shorter " 6·58 mm.

Measured seven days after germination.

In the accompanying sketch, A and B represent stages of the germinating seedling.

Brassica elata, *Ball.*

Hypocotyl undeveloped or indistinguishable from the primary root, subterranean.

Cotyledons small, transversely oblong, broadly and shallowly emarginate, slightly unequal, glabrous, rather fleshy or succulent, with a faint midrib, but no other venation apparent in the fresh state; lamina in an average of three larger ones 3·6̇ mm. long, 5·75 mm. wide; of three smaller ones 3·5 mm. long, 5 mm. wide; petioles flattened above, slightly connate at the base, unequal; average of three longer ones 4·3 mm. long; of three shorter ones 3·5 mm. long.

Leaves densely pubescent or hairy on both surfaces, petiolate.

Nos. 1 and 2. Rotund-obovate, obtusely dentate.

No. 3. Obovate, slightly lobate at the base, and obtusely dentate.

Nos. 4 and 5. Lyrate pinnatifid, with the terminal segment much the largest, rotund or oblong, dentate.

Brassica rugosa, *Roxb.*

Primary root stout, with lateral rootlets, annual.

Hypocotyl very short and tapering indistinguishably into the primary root, pale green or colourless, with its original epidermis soon splitting.

Cotyledons cuneate, bifid, with rounded obtuse lobes, petiolate, with one or at most two alternate, ascending nerves running into each lobe, glabrous, succulent, deep green above, paler beneath; lamina in an average of three larger ones 9·75 mm. long, 11 mm. wide; of three smaller ones 8·58 mm. long, 10·08 mm. wide; petioles flattened above or shallowly grooved, convex on the back, glabrous, unequal; average of three longer ones 10·08 mm. long, of three shorter ones 9·6̇.

Stem erect, terete, slightly angular, annual, glabrous, light green; two primary internodes generally undeveloped.

Leaves glabrous or slightly hairy and glabrescent when old, alternately and ascendingly penninerved, reticulate; petioles semi-terete, grooved above, stout.

Nos. 1 and 2. Spathulate, obtuse, serrato-dentate.

No. 3. Oblong, obtuse, coarsely serrato-dentate.

Nos. 4 and 5. Obovate, obtuse, coarsely, irregularly and somewhat doubly dentate-serrate, with glandular-mucronate serratures.

Brassica balearica, *Rich.*

Primary root biennial.

Hypocotyl erect, terete, glabrous, soon becoming glaucous-purple, 12–18 mm. long.

Cotyledons cuneate-obcordate, with rounded obtuse lobes on each side of the sinus, and about three alternate ascending nerves on each side, passing into the lobes, or the upper pair short and apparently formed by the forking of the midrib; deep glaucous-green above, paler and glaucous beneath, petiolate, glabrous, unequal; lamina of the longer cotyledon 8–10 mm. long, 11–13 mm. wide; of the smaller one 7–8–10 mm. long, 9–11 mm. wide; longer petiole on the larger cotyledon about 10–13 mm. long; shorter petiole 8–10 mm.

Stem erect, terete, glaucous-purple, glabrous; 1st internode 1–2·25 mm. long, 2nd 4–7 mm.

Leaves glabrous, glaucous, with the midrib and principal nerves purple, alternately penninerved, reticulate.

No. 1. Obovate, slightly crenate.

No. 2. Oval, coarsely crenate.

Nos. 3 and 4. Suborbicular or oblong-orbicular, coarsely and irregularly crenate, slightly decurrent on the petiole in small lobules.

No. 5. Oblong, obtuse, lobulate and crenate, decurrent on the petiole forming small lobules.

Brassica Aristidis, *Coss.*

Hypocotyl erect or procumbent, terete, green or purple, glabrous or nearly so, slightly striate, soon losing its epidermis by splitting, 8–15 mm. long.

Cotyledons very similar to those of B. balearica, fleshy, light green above, paler or glaucous beneath; average of the three larger laminæ 13·3 mm. long, 15·4 mm. wide; of three longer petioles 15·83 mm. long, of the shorter 14·6 mm.

Stem developed when about to flower; primary internodes undeveloped.

Leaves radical and cauline, alternately penninerved, pubescent on both surfaces with adpressed hairs.

No 1. Small, obovate, shallowly crenate.

No. 2. Deltoid, obtuse, coarsely crenate.

Nos. 3 and 4. Deltoid, obtuse, coarsely crenate, somewhat decurrent and slightly lobulate on the petiole.

Nos. 5 and 6. Lyrate, pinnatifid, lobulate and coarsely crenate: terminal lobe much the largest, deltoid, lobulate, and coarsely crenate.

Orychophragmus sonchifolius, *Bunge.*

Hypocotyl erect, striated, covered with very minute almost globular hairs, 10·12 mm. long, colourless with a slight purplish tinge towards the upper part.

Cotyledons broadly ovate-oblong, obtuse, minutely emarginate, petiolate, glabrous, green above, stained with dark purple beneath, indistinctly one-veined; petioles rather long, covered with very minute hairs, channelled on the upper side.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, exstipulate, petiolate, subrotund or oblong, serrate, acute, hairy, light green, pinnatinerved.

Moricandia hesperidiflora, *DC.*

Primary root tapering downwards with numerous lateral rootlets.

Hypocotyl erect, terete, glabrous, 4–4·5 cm. long, light green or colourless.

Cotyledons transversely oblong, emarginate, petiolate, glabrous, unequally divided by the midrib; midrib with a few ascending veinlets; petioles 1·5–2 cm. long.

Stem with the primary internodes undeveloped.

First leaves simple, cauline, alternate, lanceolate, bluntly serrate, petiolate, glabrous, light green; midrib with numerous ascending veinlets.

Moricandia arvensis, *DC.*

Primary root as in the preceding species.

Hypocotyl as in the preceding species but 8–10 mm. long.

Cotyledons unequal, obovate, slightly emarginate, fleshy, with a long flat petiole, glabrous, green, indistinctly one-veined.

Stem erect, herbaceous, terete, glabrous, pale green; first internode 1–2 mm. long.

First leaves obovate, notched at the apex, obtuse, tapering to the flat petiole.

Carrichtera Vellæ, *DC.*

Hypocotyl erect, terete, hairy or villous, 2–3·5 cm. long.

Cotyledons bifid, broader than long, nearly or quite glabrous, petiolate; lamina 4–5 mm. long, 5–6 mm. wide, subtruncate or distinctly cuneate at the base; petiole thinly pilose, semiterete, channelled above, 7–8 mm. long. The internodes between the cotyledons are sometimes elongated, making the latter alternate.

Stem herbaceous, erect, annual, hairy with deflexed hairs; internodes elongated.

Leaves simple, cauline, alternate, exstipulate, petiolate, almost glabrous above, thinly hairy beneath; petiole semiterete, channelled above.

No. 1. Pinnatifid or pinnatisect with linear segments.

No. 2. Similar.

Nos. 3 and 4. Pinnatisect, with slender segments.

Nos. 5 and following. Bipinnatisect with slender segments.

Succovia balearica, *Medik.*

Hypocotyl erect, terete, but with a distinct rather deep furrow along its whole length, from the edges of the cotyledons to the base, glabrous.

Cotyledons petiolate, with a bipartite lamina, unequal; lamina transverse with two orbicular or obovate, often unequal lobes, consisting of lateral developments, growth in length being very limited and represented by the undivided portion, the midrib terminating at the base of the sinus. The rounded form of the lobes is due to their shape in the globular seed as each lobe occupies about half the area of the cavity. Each is traversed by two lateral nerves from the midrib, which curve and unite with one another within the margin. The base of the lobes is somewhat auricled, passing into the narrow cuneate leaf-base. Petioles of unequal length, rather deeply channelled above.

Stem erect, herbaceous, slightly pubescent, with shallow ridges from the bases of the leaves.

Leaves, the first two opposite or alternate, five-lobed, with the terminal lobe trifid, and the lateral ones oblong or ovate and slightly toothed, a small basal lobe being sometimes present, glabrous. The other leaves are alternate.

Capsella Bursa-pastoris, *Mœnch* (fig. 170).

Primary root long, tapering, colourless, with lateral rootlets, annual.

Hypocotyl subterranean.

Cotyledons small, spathulate, obtuse, petiolate, glabrous.

Stem undeveloped till the time of flowering.

Leaves radical (ultimately cauline), alternate, exstipulate, petiolate, coarsely hairy on both surfaces; petioles convex beneath, much flattened above, broad.

Nos. 1 and 2. Entire with a rotund limb. After these an uncertain number are spathulate and entire or oblong and variously dentate.

Ultimate leaves lyrate, pinnatifid or pinnatipartite; terminal lobe ovate, obtuse, irregularly dentate; middle lobes ovate, obtuse, very unequal on the anterior side, with an extra longitudinal vein and irregularly toothed or lobed; basal lobes small.

Cauline leaves ovate, lanceolate and linear, deeply auricled at the base, amplexicaul, sessile, serrate.

Lepidium sativum, *L.* (figs. 171–2).

Fruit a silicula; septum narrow, laterally compressed, each carpel boat-shaped and falling away from the placenta, containing one, rarely two seeds.

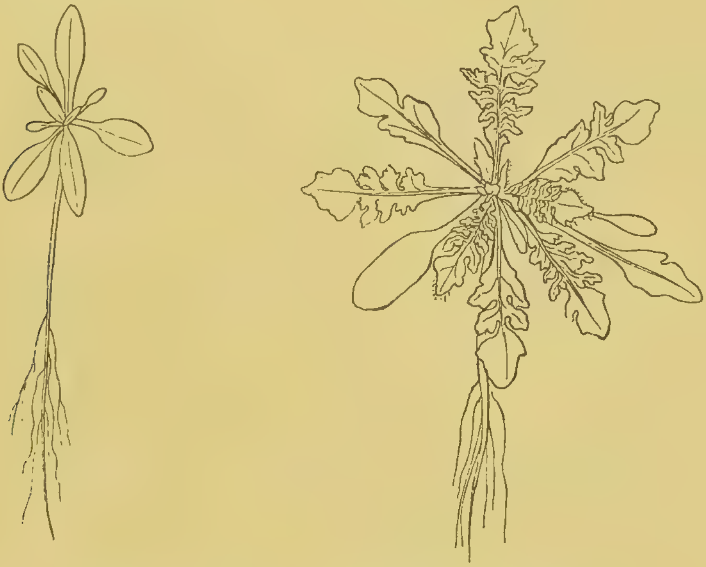

FIG. 170.—*Capsella Bursa-pastoris.* Nat. size.

Seed oblong, trigonous, pale brownish-yellow, with the narrow or dorsal aspect (containing the radicle) lying in the keel of the carpel, to which it conforms roughly in shape, with the broader ventral aspect to the septum, curved upon itself so that the basal part of the radicle lies in a separate cavity from that of the cotyledons; hilum at the upper end of the seed; micropyle superior on the dorsal aspect.

Embryo large, curved upon itself, conforming in shape to the seed, yellowish; cotyledons tripartite (*v. ante*, p. 52), shortly petiolate; middle segment oblong, obtuse, longer than the other two, which are similar but shorter and packed on the back of the middle one, all placed with their backs to the placenta; radicle nearly as long as the incumbent cotyledons, cylindrical, pointed.

Lepidium graminifolium, *L.*

Seed (fig. 171) *v, ante*, p. 52.

Seedling (fig. 173).

Primary root slender, tapering downwards, with fibrous lateral rootlets.

Hypocotyl very short, tapering indistinguishably into the primary root.

Cotyledons unequal, oblong, obtuse, entire or minutely emarginate, petiolate, with short ascending or irregular lateral nerves anastomosing with one another and discernible only by transmitted light, glabrous, light green; lamina of the smaller one 5·5–7·5 mm. long, 3·5–4·5 mm. wide; of the larger one 7–10·5 mm. long, 4–5 mm. wide; petiole flattened above, convex beneath, connate at the base, glabrous; shorter one 4–5 mm., longer 5·5–7 mm. long.

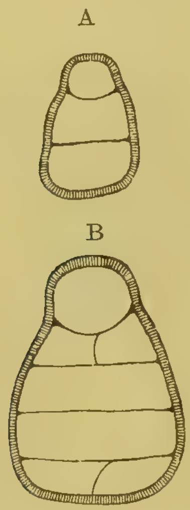

Fig. 171.—Transverse section of seed of *Lepidium* spp., × 15.

A, *L. graminifolium.*
B, *L. sativum.*

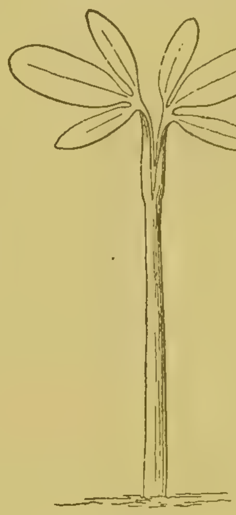

Fig. 172.
Lepidium sativum, × 3.

Stem herbaceous, forming a persistent rootstock and sending up flowering stems; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, alternately penninerved with the nerves running directly into the teeth or more often incurved, uniting with one another, sending branches into the marginal teeth and more or less distinctly reticulate, ciliate at the margins when young, glabrescent, green above, paler beneath; petioles semiterete, channelled above, dilated and clasping with a usually ciliate margin at the base.

Nos. 1 and 2. Elliptic or oval, obtuse, somewhat tapered towards the base, obtusely and distantly serrate-crenate.

Nos. 3 and 4. Elliptic, obtuse, tapered to the base, more deeply serrate-crenate.

Lepidium spinosum, *L.*

Hypocotyl erect, terete, glabrous, 1–2 cm. long, light green or colourless.

Cotyledons oval-oblong, fleshy, entire, petiolate, glabrous, dull green, indistinctly one-veined.

Stem short; primary internodes undeveloped.

First leaves simple, cauline, obovate or oblong, subacute, coarsely serrate or even crenate, petiolate, glabrous, light green, indistinctly pinnatinerved.

Senebiera didyma, *P.*

Primary root long, tapering and normal, annual.

Hypocotyl subterranean, tapering downwards into the root.

Cotyledons opposite, linear - spathulate, obtuse, tapering to the petiole, 6–8 mm. long including the petiole, glabrous.

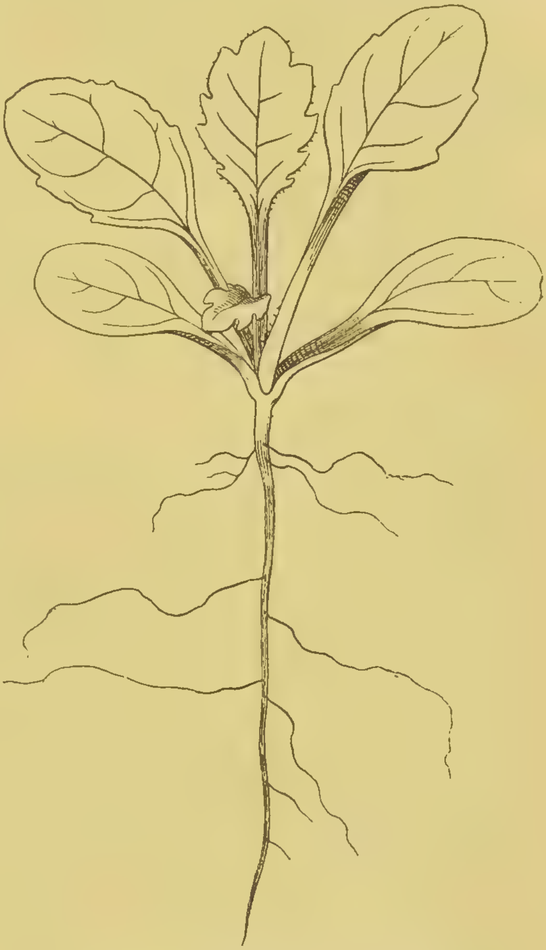

FIG. 173.—*Lepidium graminifolium,* × 2.

Stem developing later, decumbent, leafy.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, glandular; glands sessile, with a disagreeable smell.

No. 1, and frequently Nos. 2 and 3. Entire with an oblong-obtuse or spathulate lamina. Further stages of leaves are oblong, pinnatifid, with elliptic, bristle-tipped segments; terminal lobe largest, entire or trifid.

Ultimate leaves linear, pinnatisect; terminal lobe deeply trifid with generally entire segments; lateral lobes half-ovate, obtuse, again pinnatifid, but lobes usually all on the anterior side, or with one tooth only on the posterior side; segments all tipped with a bristle.

Æthionema gracile, *DC.*

Hypocotyl 2–6 mm. long.

Cotyledons suborbicular, more or less unequal at the base, entire or sometimes emarginate, fleshy, with a few short, simple or slightly branched hairs on the upper surface, shortly petiolate; lamina 4–5·5 mm. long, the difference between the unequal sides varying from ·25–·75 mm.; petiole flattened above, 2·5–3 mm. long.

Stem with more or less developed internodes, terete, covered with stellate hairs.

Leaves simple, entire, showing a midrib only, covered more or less densely on both surfaces with white, stellate hairs.

1st to 5th pairs in the seedling state small, cauline, opposite and decussate, elliptic, subacute or obtuse.

Bivonæa Saviana, *Caruel.*

Hypocotyl terete, 4–5 mm. long, soon losing its epidermis by splitting.

Cotyledons shortly oblong, obtuse, minutely emarginate, tapering slightly at the base, petiolate, glabrous; the succulent lamina 5·5–7·5 mm. long, 4–5 mm. wide; petiole long, slender, spreading horizontally and upcurved, semiterete, channelled on the upper side, dilated at the base and slightly connate, 1·6–2·2 cm. long.

Stem with the internodes undeveloped.

Leaves simple, radical, alternate, petiolate, glabrous, succulent, venation indistinct, veins radiating from the base and becoming incurved upwards, deep green above, paler beneath, with a more conspicuous venation; petiole very long, tapering upwards from a dilated base, channelled on the upper side.

Nos. 1–6. Reniform-cordate, obtuse, entire.

Nos. 7–10. Similar but having one or two angles or teeth near the base on each side.

Menonvillea trifida, *Steud.*

Hypocotyl erect, terete, glabrous, 2–3 cm. long, light green or colourless.

Cotyledons long, linear, acute, curled at first, sessile, glabrous, pale green.

Stem with primary internodes undeveloped.

First leaves simple, cauline, alternate, pinnati-fid or -partite; segments two, linear, acute, hairy.

Biscutella didyma, *L.*

Primary root tapering downwards, with numerous lateral rootlets.

Hypocotyl short, tapering sharply downwards, almost colourless, glabrous, from 1–2 mm. long.

Cotyledons fleshy, broadly oblong, obtuse, entire or very minutely crenate at the apex, rather unsymmetrically divided by the midrib, shortly petiolate, glabrous, green, indistinctly pinnatinerved like the leaves, cuneate at the base.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, petiolate, subrotund or oblong, obtuse, crenate, hairy, green, pinnatinerved; petioles rather short, hairy, rather flat and channelled on the upper side.

Iberis corifolia, *Sweet.*

Primary root tapering downwards and branched.

Hypocotyl erect, terete, glabrous, 14–18 mm. long.

Cotyledons shortly and broadly oval, obtuse, entire, petiolate, glabrous; lamina opaque with an indistinct midrib, 10 mm. long by 7 mm. broad; stained purple beneath, petiole 4–4·5 mm. long, slightly channelled on the upper side.

Stem herbaceous or subshrubby, erect in the seedling stage, afterwards procumbent, scabrous, otherwise glabrous; 1st internode 4–5 mm. long.

Leaves simple, entire, cauline, alternate (1st pair opposite or nearly so), petiolate, narrowed to the base, glabrous, one-nerved, deep green, all narrower than the cotyledons.

Nos. 1 and 2. Obovate-spathulate, obtuse.
Nos. 3–5. Spathulate, obtuse.
Nos. 6–10. Linear, obtuse.

Iberis Lagascana, *DC.*

Hypocotyl 5–8 mm. long.

Cotyledons oval-oblong, fleshy, rather unsymmetrical.

Stem with primary internodes undeveloped.

Leaves pinnatifid, cauline, alternate, glabrous except on the petioles, light green, pinnatinerved; lobes entire, obovate, obtuse; petiole channelled on the upper side, with a few scattered hairs.

Iberis pectinata, *Boiss.*

Hypocotyl 10–18 mm. long.

Cotyledons obliquely oval, very unequal at the base, obtuse, somewhat truncate at the apex, or faintly emarginate, glabrous or with a thin, faint line of adpressed colourless hairs along the back of the petiole; lamina in average specimens 9–10 mm. long on one side of the midrib, and 8 mm. on the other, about 7 mm. wide; petiole 12–14 mm. long, channelled on the upper side.

Stem terete, hairy, with spreading or deflexed hairs; internodes variously developed from 1–15 mm.

Leaves cauline, hairy, with a distinct channelled midrib.

Nos. 1–7. Linear, obtuse, tapering gradually into the petiole at the base, deeply and bluntly toothed or pinnatifid.

Isatis tinctoria, *L.* (fig. 174).

Fruit laterally compressed, oblong-cuneate, broadest at the apex, somewhat winged at the base and apex, woody on each side of the cavity containing the seed, one-celled, one-seeded, indehiscent.

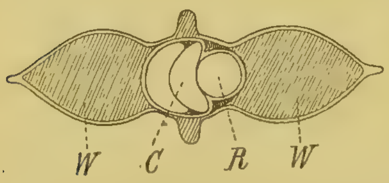

FIG. 174.—*Isatis tinctoria*. Transverse section of fruit, × 8: *C*, cotyledons; *R*, radicle; *W*, *W*, woody portions of siliqua.

Seed cylindrical or oblong, tipped with the short funicle by which it is suspended from the apex of the cell; hilum and micropyle contiguous, at the upper end of the seed, and nearest the base of the style.

Endosperm none, or forming an extremely thin film on the inner face of the testa.

Embryo large, filling and conforming to the seed, curved or bent upon itself, yellowish; cotyledons oblong, obtuse, entire; radicle spindle-shaped, narrowed to an obtuse point, lying along the back of the (incumbent) cotyledons and slightly longer by reason of its forming the curve at the apex of the seed while the cotyledons are straight.

Ochthodium ægyptiacum, *DC.* (fig. 175).

Fruit a nut-like silicula, broadly rhomboid, short, subquadrangular, laterally compressed, covered with hard tubercles on the four angles and smaller ones between; subcarinate on the back of each carpel, glabrous, pale grey, two-celled, two-seeded, indehiscent and remaining attached to the pedicel; pericarp hard, crustaceous, and somewhat brittle.

Seed broadly oblong, rounded at the apex, unequal at the base owing to a prolongation of the radicle beyond the cotyledons, compressed but convex dorsally, nearly flat ventrally, pale yellow; testa thin, membranous; micropyle superior, contiguous to, but a little higher up than, the hilum; chalaza forming a small, slightly thickened deep brown spot, close to the sinus between the cotyledons and the radicle, in which the hilum is placed.

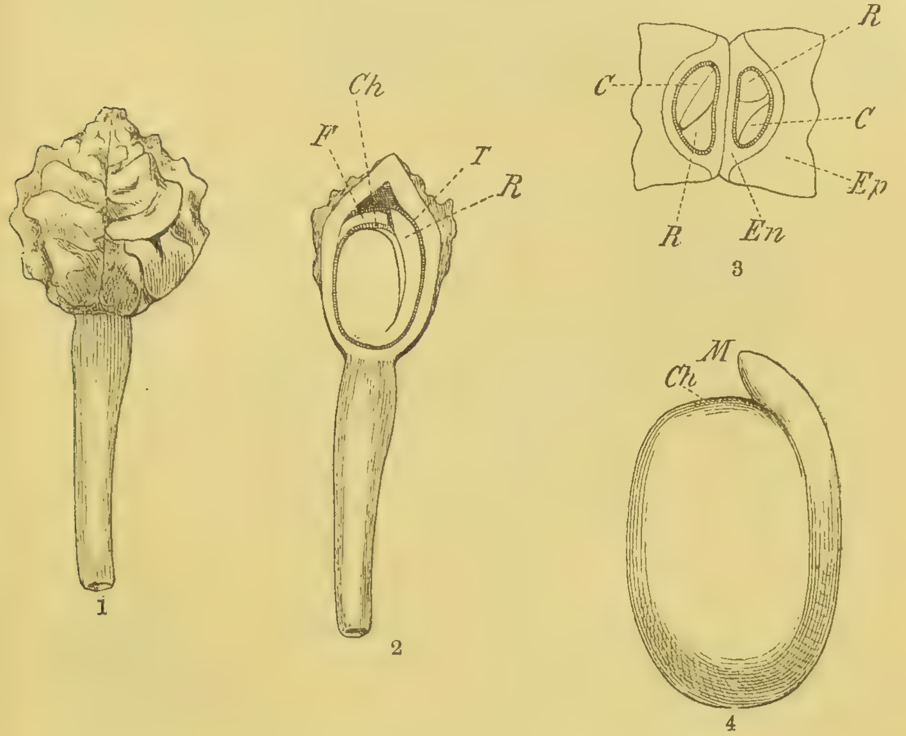

FIG. 175.—*Ochthodium ægyptiacum.*

1, Fruit on its pedicel, × 6, lateral aspect.

2, Longitudinal section of fruit, × 6: *F*, funiculus; *T*, testa; *R*, radicle; *Ch*, chalaza.

3, Transverse section of fruit, × 6: *C*, *C*, cotyledons; *R*, *R*, radicles; *Ep*, epicarp *En*, endocarp.

4, Seed, × 15: *Ch*, chalaza; *M*, micropyle.

Endosperm absent.

Embryo comparatively large and filling the entire seed, doubled upon itself, pale yellow or nearly colourless; cotyledons oblong-oval, obtuse, plano-convex, obliquely incumbent; radicle somewhat curved, lying obliquely on the back of the cotyledons, but between the latter and the septum, that is on the ventral aspect, rather longer than the cotyledons.

Bunias orientalis, *L.*

Fruit nut-like, ovoid-tetragonous, laterally compressed, more or less tuberculated or rough at the angles, tipped with the persistent base of the style, woody, pale-coloured, indehiscent, one- to two-celled, with generally a seed in each cell.

Seed more or less cochleate by the shrinking of the testa to conform to the embryo, otherwise, when fresh and plump, nearly globose with the radicle appearing as an appendage at one side; micropyle close to and superior to the hilum; chalaza forming a broad orbicular discoloured patch on the ventral aspect.

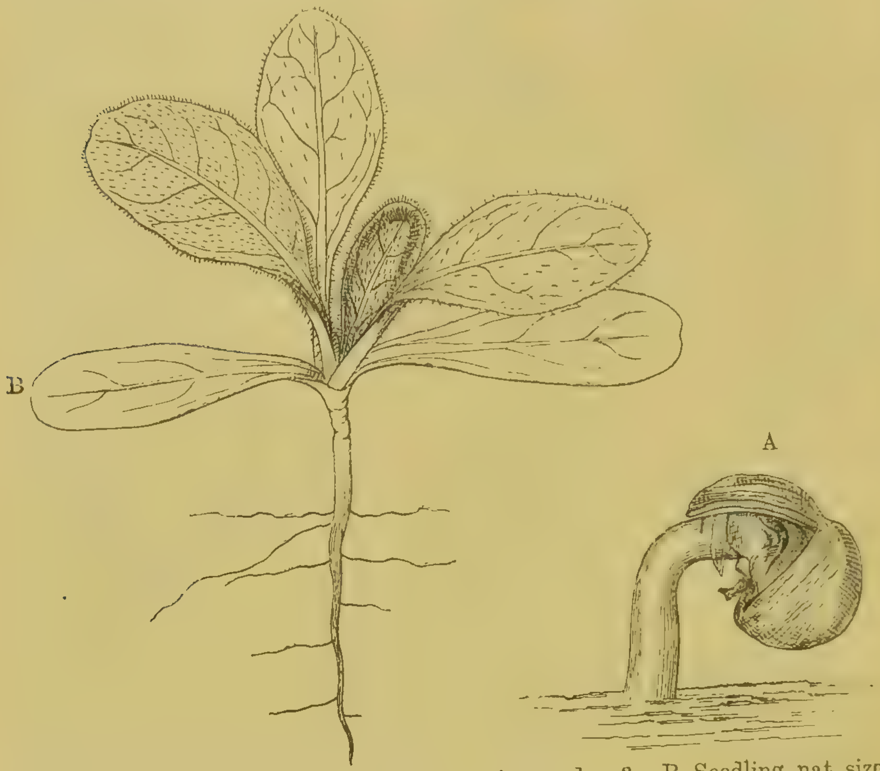

Fig. 176.—*Bunias orientalis.* A, Germinating seed, × 3. B, Seedling, nat. size.

Endosperm in the mature seed forming a thin film lining the interior of the testa.

Embryo large, filling the seed, spirally coiled, pale yellow; cotyledons oblong, obtuse, entire, forming about a coil and a half, with their tips in the centre of the coil, and the edges of both touching the sides of the seeds, narrowed to the base; radicle cylindrical, obtuse, incumbent and curved round close to the hilum and beneath the base of the style, long, and well developed.

Seedling (fig. 176).

Hypocotyl very short, stout, erect, wrinkled transversely, pale green or colourless, 2–6·5 mm. above the soil.

Cotyledons unequal in length, spathulate, obtuse, entire, or showing a tendency to become emarginate, tapering to a petiole-like base, with a few alternate, ascending slender nerves, the uppermost strong pair of which incurve and unite with the midrib below the apex, finely reticulate, and all the veins seen only by transmitted light, glabrous, light green above, paler beneath, petioles flattened above, convex beneath, slightly connate at the base; average length of three long cotyledons 4·2 cm., of three short ones 3·33 cm.

Stem herbaceous, developed when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, petiolate, hairy on both surfaces, alternately and ascendingly incurvinerved; nerves uniting at the apex, obscurely reticulate; petiole tapering upwards from a rather broad, clasping base, channelled on the upper side, or finally becoming more or less flattened.

Nos. 1 and 2. Spathulate-obovate, or oblong, or oval, obtuse, entire, or with inconspicuous glandular teeth.

No. 3. Similar.

No. 4. Oblong, obtuse, entire, with glandular teeth.

Zilla myagroides, *Forsk.*

Fruit a nut-like silicula, ovoid or subglobose, slightly compressed laterally, shallowly ridged and furrowed longitudinally, tipped with the subulate or conical, persistent style, two-celled, two-seeded, indehiscent, glabrous, pale ashy grey, or more or less blackened; substance of pericarp differentiated into an outer, thick, pale-coloured, corky layer, and an inner, thick, hard and almost bony layer furnished with wings extending through the cortex to the circumference of the fruit.

Seed obovoid, conforming to the cavity of the loculus, somewhat compressed, but convex dorsally; much compressed and almost flattened ventrally, pale brown, smooth, almost shining, very unequal at the upper and basal end where it runs out at one side into an obtuse point; testa comparatively thin, coriaceo-membranous; hilum in the sinus formed by the curvature of the seed, that is between the radicle and the part containing the cotyledons; micropyle at the upper and most elongated point of the seed; chalaza lateral, forming a dark brown spot near the hilum, but on the opposite side of the latter from the micropyle.

Endosperm absent.

Embryo large and filling the seed, doubled upon itself.

Cotyledons rotund-cuneate, emarginate, conduplicate, and incumbent, probably about equal in size, as the inner one projects some way from beneath the outer, pale yellow; radicle cylindrical, subfusiform, slightly curved in conformity with one side of the seed, much longer than the cotyledons, and terminating in the pointed end of the seed, considerably curved at its union with the cotyledons, pale yellow, obtuse.

For further development see Goebel, 'Flora,' 1889, p. 32.

Seedling (fig. 177).

Hypocotyl erect, terete, glabrous, pale green, 6–18 mm. or more above the soil.

Cotyledons unequal, broadly cuneate, emarginate or broadly and shallowly bifid, petiolate, with one or two alternate, ascending, difficultly discernible nerves entering the lobes, rather fleshy, glabrous, bright green; lamina of the smaller one 6·5–8 mm. long and as wide; of the larger 8·5–10 mm. long and 7·5–11 mm. wide; petiole semiterete, flattened above, slightly connate at the base, glabrous, light green; of the smaller cotyledon 8–10 mm., of the larger 7·5–8·5 mm. long.

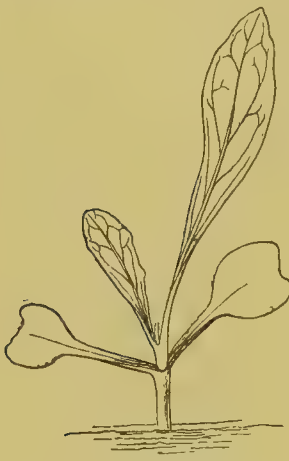

Fig. 177.
Zillamyagroides. Nat. size.

Stem erect, terete, glabrous, pale green, ultimately shrubby; first internode ·5–2 mm. long.

Leaves simple, cauline, alternate, petiolate, alternately and ascendingly penninerved with the nerves incurved uniting at their apex and anastomosing indistinctly, with a prominent midrib, but the other venation best discernible on the under side, rather fleshy, glabrous, light subglaucous-green, and somewhat shining when young; petioles slightly flattened above or biconvex with a prominent midrib, glabrous.

Nos. 1 and 2. Spathulate, obtuse, with rather long petioles, and one to two obscure or obsolete teeth on each side.

Cakile maritima, *Scop.* (fig. 178).

Hypocotyl erect, terete, glabrous, 4·5–5 cm. long, light green or colourless.

Cotyledons unequal, rather fleshy, linear, obtuse, entire, sessile, tapering to the base, but not petiolate, glabrous, light green, oneveined.

Stem erect, terete, herbaceous.

Cakile americana, *Nutt.*

Hypocotyl as in C. maritima but only 5–10 mm. long.

Cotyledons very unequal, linear-oblong, otherwise as in C. maritima.

Stem with primary internodes undeveloped.

First leaves simple, entire, cauline, alternate, narrowed to the base, exstipulate, ovate-oval, obtuse, very hairy, light green, pinnatinerved.

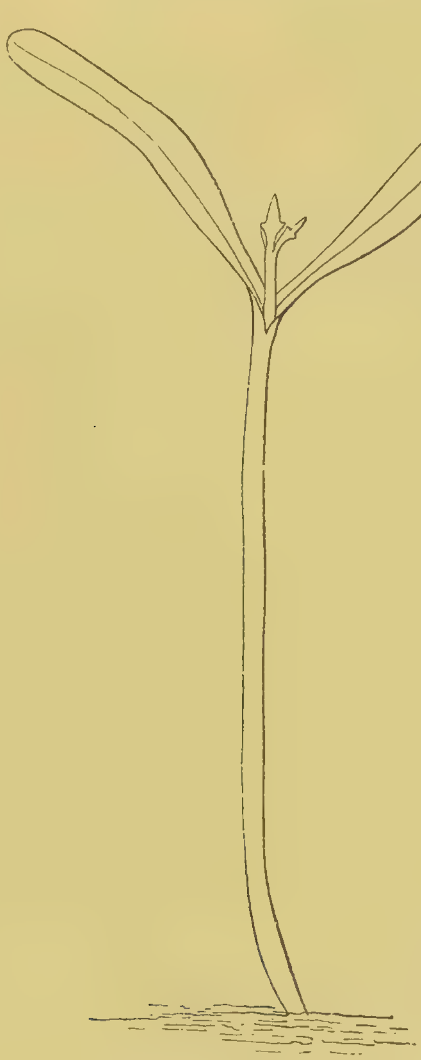

Fig. 178.—*Cakile maritima*, × 2

Chorispora tenella, *DC.*

Hypocotyl short, erect, scarcely appearing above the soil obconical.

Cotyledons oval-oblong, obtuse, entire, petiolate, rather fleshy, glabrous, green, pinnatinerved like the leaves; petiole long, rather flat, slightly furrowed on the upper face.

Stem with primary internodes undeveloped.

First leaves simple, cauline, alternate, petiolate, obovate-oblong, obtuse, lobed (first one entire), slightly hairy, green, pinnatinerved; petioles rather long, channelled on the upper face.

Raphanus sativus, *L.*

For description of seed see above, p. 31 (fig. 62).

Seedling (fig. 179).

Primary root long, tapering, flexuose, with a few small lateral rootlets.

Hypocotyl short, stout, succulent, subsequently becoming swollen to form the edible *radish*, glabrous, purple, merging into the root.

Cotyledons opposite, foliaceous, with long petioles, penninerved, glabrous; lamina obcordate or obreniform; petiole broadly and shallowly grooved on the upper side, dilated and connate at the base.

Stem erect, shallowly ridged and furrowed, sparsely setose or scabrid, pale green, sometimes suffused with purple; 1st internode 2–6 mm. long; 2nd 1·5–3·5 cm., very variable under cultivation.

Leaves simple, cauline, alternate, petiolate, sparsely setose or scabrous, oblong or linear, simply toothed or serrate or variously lyrate-pinnatifid; segments obtuse and entire or variously and irregularly pinnatifid or toothed.

NOTE.—When there is abundance of moisture the plants grow freely and the leaves are little cut up, varying from spathulate or oval to oblong, lyrate-pinnatifid or pinnatisect. If the plants are crowded or the weather dry they swell but little at the root, run to flower, and at the same time produce leaves that are bipinnatisect or irregularly cut into narrow shreds or segments.

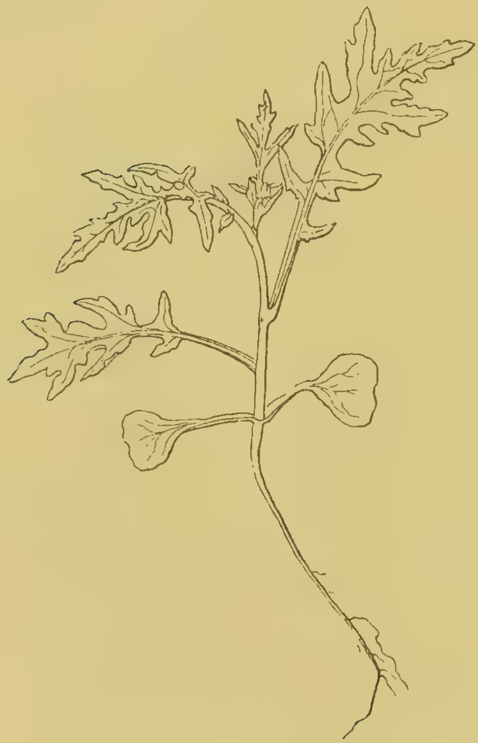

FIG. 179.—*Raphanus sativus.* Nat. size.

CAPPARIDEÆ.

Benth. et Hook. *Gen. Pl.* i. 103.

Fruit and Seed.—The Order falls into two divisions according as the fruit is dry and capsular as in Cleome, Cleomella, Cristatella, and others; or on the other hand baccate like Capparis, Morisonia, and Mærua, or drupaceous as in the one-seeded fruit of Roydsia. In the capsular types, the Order approaches Cruciferæ very closely. The fruit is siliquose in all the genera of the Cleomeæ except Wislizenia and Oxystylis, where it is short, didymous, and breaks up into indehiscent one-seeded pieces. The Cappareæ have baccate and indehiscent fruits with the seeds embedded in pulp. The ovules in all cases are parietal, campylotropous or semianatropous, and the seeds reniform in the dry fruits, reniform or angular in the baccate fruits. The angular condition may depend upon the number of seeds in a fruit and the effect of mutual pressure. When the pulp is plentiful, separating the seeds from one another, they retain the usual shape of the campylotropous ovules. Usually the seeds are exalbuminous, but there is a thin layer of endosperm surrounding the embryo of Capparis sandwichiana (fig. 182) and a thick layer in which the curved embryo is embedded in Tovariå, an anomalous genus containing only one species, referred to the Papaveraceæ by Eichler and compared with the Phytolaccaceæ by Bentham and Hooker. It is probable that a careful examination of many species would reveal the presence of endosperm in other cases besides Capparis sandwichiana. The testa is thick, coriaceous, and smooth or often rough in species with a capsular fruit. The embryo is bent or incurved, or spirally convolute, and the cotyledons are incumbent, plaited or convolute, and induplicate, as may be seen by reference to the transverse section of Capparis sandwichiana.

Cotyledons.—As far as observed (seeds and seedlings of different species being difficult to obtain) the cotyledons after germination are always broad, petiolate, obtuse, and entire, and in some cases at least unequal in size. The breadth is of course due to their being folded longitudinally, as well as to the comparatively large size of the seed and embryo.

The cotyledons of a species of Capparis (fig. 183) from Melbourne were large, foliaceous, shortly petiolate, ovate, obtuse, alternately incurvinerved and reticulate, glabrous, convex above, slightly unequal-sided, that is, the portion of lamina on each side of the midrib was not of the same width. They were evergreen and persisted for more than a year on the plant. In the case of Cleome violacea they fall away early.

Cleome violacea, *L.* (fig. 180).

Primary root tapering downwards, strongly tortuose, with a few lateral roots, annual.

Hypocotyl very short, stout, colourless, terete, subterranean, tapering into the root.

Cotyledons falling away early, slightly unequal, oblong or ovate-oblong, obtuse, entire, petiolate; petioles a little shorter than the lamina.

Stem erect, terete, herbaceous, annual, pale green, densely glandular-pubescent; 1st internode 2·25 mm. long; 2nd hardly developed; 3rd 6 mm. long; 4th 6 mm.; 5th 9·5 mm.; 6th 1·7 cm.; 7th 1·6 cm.; 8th 8·5 mm.; 9th 1·15 cm.; 10th 1 cm.; 11th 1·1 cm.; 12th 1·8 cm.; 13th 1·1 cm.; 14th 1·35 cm.; 15th 1·5 cm.; 16th 1·5 cm.; 17th 1·1 cm.; 18th 7 mm.; 19th 4·5 mm.; 20th 2 mm.

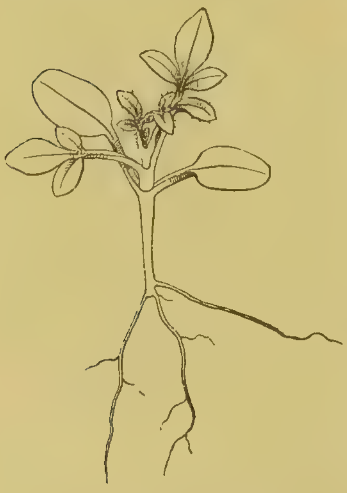

Fig. 180.—*Cleome violacea*, × 2.

Leaves compound, digitately trifoliate, ultimately unifoliolate, cauline, alternate (first two opposite), exstipulate, petiolate, glandular-pubescent on both surfaces, deep green above, glaucous beneath; leaflets oblong-linear, obtuse or subacute with a deeply channelled midrib, very prominent beneath; petioles subterete, channelled on the upper side.

Nos. 1 and 2. Small, trifoliolate; leaflets subelliptic, the terminal one largest.

Nos. 3–6. Gradually larger, trifolioliate; leaflets linear.

No. 7. With one large terminal leaflet and a small lateral one.

Nos. 8–14. With one rather long terminal leaflet.
The rest are bracts bearing flowers in their axils.

Cleome spinosa, *L.* (fig. 181).

Primary root with numerous strong lateral rootlets.

Hypocotyl erect, terete, glandular-pubescent near the top, otherwise glabrous, striated longitudinally, and marked with two lines of crystalline elevations running down from the edges of the cotyledonary petioles, deep dull red, 8–15 mm. long.

Cotyledons often, if not always, unequal, oblong or more often ovate-oblong, obtuse, entire, with a few alternate, ascending or sub-incurved nerves, dull green above, paler beneath, petiolate; lamina glabrous, 8–12 mm. long, 3–6 mm. wide; petioles semi-terete, slightly channelled above, densely glandular-pubescent, each 3–5·5 mm. long.

Average length of 3 laminæ, 10·3̇ mm. and 9·3̇ mm. in the longer and shorter cotyledons respectively.

Stem glandular-hairy; 1st internode hardly developed, or ·5–1 mm. long.

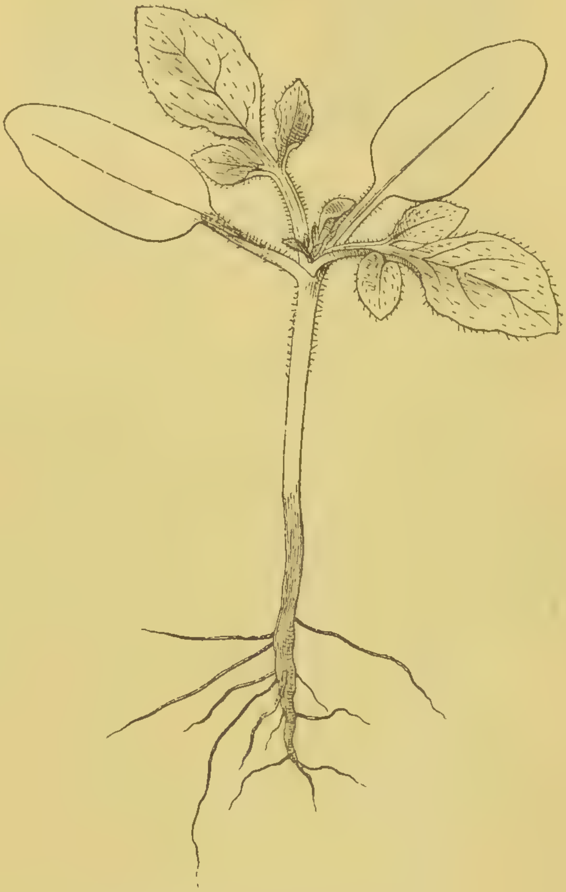

Fig. 181.—*Cleome spinosa*, × 2.

Leaves ternately pinnate, alternate (first two opposite), glandular-pubescent on both surfaces, and rather strongly ciliate at the margin, alternately and ascendingly penninerved; petioles semi-terete, channelled above, densely glandular-pubescent.

Nos. 1 and 2. Opposite, pinnately ternate; leaflets petiolulate; terminal one largest, elliptic, obtuse or subacute, slightly undulate at the margin or flat; lateral leaflets similar but much smaller.

Capparis sandwichiana, *DC.* (fig. 182).

Fruit stipitate, globose or cylindrical, baccate, many-seeded, indehiscent.

Seed reniform, slightly flattened, embedded in pulp, with very unequal ends—the smaller containing the radicle, the larger the cotyledons; testa black, smooth, crustaceous; inner coat membranous; hilum in the basal notch.

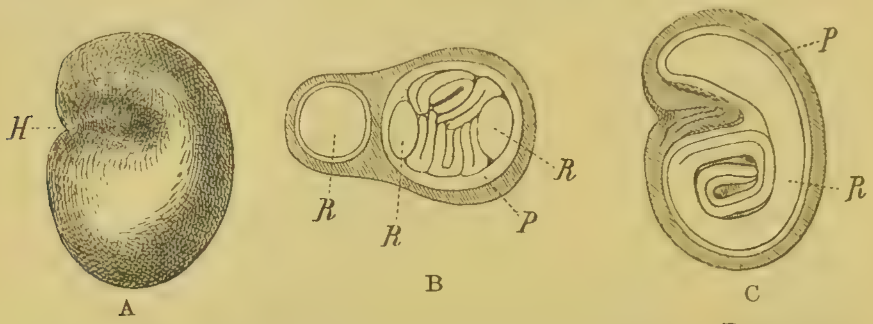

Fig. 182.—*Capparis sandwichiana.* A, seed, × 8: *H*, hilum. B, transverse section of seed, × 8: *R*, *R*, *R*, radicle; *P*, endosperm. C, longitudinal section of seed, × 8: *P*, endosperm; *R*, radicle.

Endosperm forming a thin layer surrounding the embryo.

Embryo large, spirally coiled, colourless; cotyledons oblong, each separately conduplicate, and then the double fold coiled spirally, one each side of the seed with its back to the endosperm, and both its edges lying in the centre of the seed and abutting against the edges of the other cotyledon; radicle long, cylindrical, obtuse, incumbent, and forming a complete coil round the cotyledons and along the periphery of the seed.

Capparis, *sp.* (fig. 183).

Hypocotyl woody, erect, compressed, tapering upwards, glabrous, glaucous-green, 2·8 cm. long.

Cotyledons large, foliaceous, ovate, obtuse, alternately incurvinerved and reticulate, glabrous, deep green and convex above, shallowly concave and scarcely paler beneath, shortly petiolate; lamina 2·85 cm. long, 1·7 cm. broad; petiole 1·5 mm. long, persistent. In the specimen sketched the halves of the cotyledons are of unequal widths by 1 mm. The inequality of the one does not correspond to that of the other.

Stem woody, erect, terete, pubescent, pale green; 1st internode 8·5 mm. long; 2nd 4 mm.; 3rd 1 mm.; 4th 1·55 cm.; 5th 1 cm.; 6th 8 mm.; 7th 1·15 cm.; 8th 3·25 mm. First branch in axil of a cotyledon.

Leaves simple, entire, cauline, alternate, exstipulate, shortly petiolate, ascending, alternately penninerved and obscurely reticulate, glabrous, and nearly of the same deep green on both surfaces; petioles very short (about 1 mm. long), stout, articulated with the stem; stipules small, spreading, spinous, pale yellowish-brown, absent from the first three leaves.

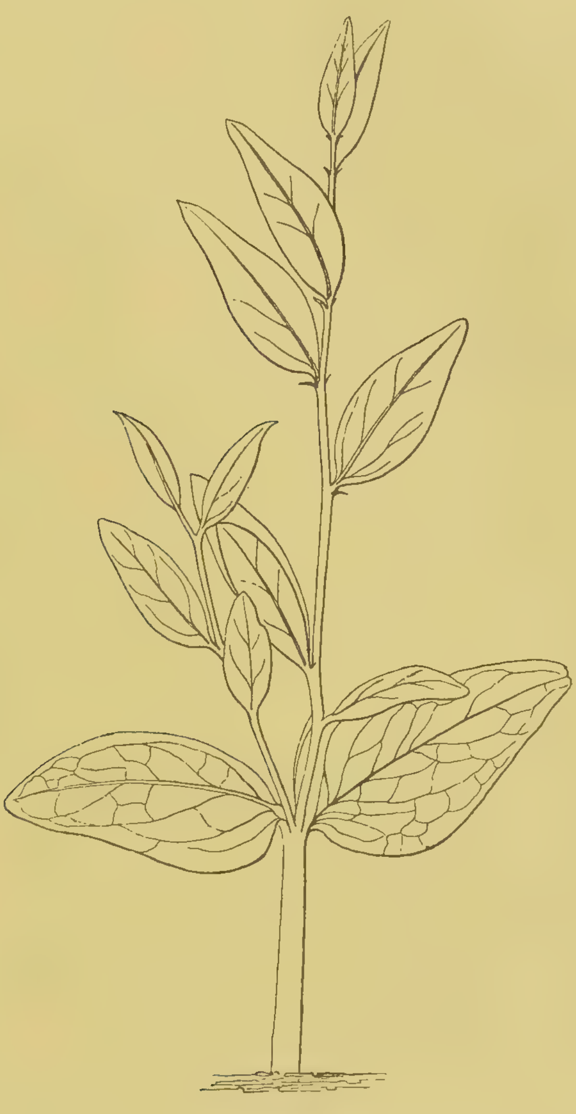

FIG. 183.—*Capparis*, sp. Nat. size.

Nos. 1–3. Narrowly oblong, elliptic, obtuse, subapiculate.

No. 4. Lanceolate, obtuse.

Nos. 5 and 6. Lanceolate, acute.

Nos. 7 and 8. Small, lanceolate, obtuse.

RESEDACEÆ.

Benth. et Hook. *Gen. Pl.* i. 110.

The Resedaceæ constitute a small Order, containing from thirty to sixty species according to the view taken by different authors. The greater part of them are natives of dry countries such as South Europe, North Africa, Syria, Asia Minor, and Persia, with a few in the outlying provinces of India, and three in Cape Colony. They consist of annual or perennial herbs, and a few are shrubby. The leaves are alternate and scattered, or crowded on short undeveloped branches, simple and entire or trifid or pinnatisect.

Fruit and Seed.—The ovary consists of from two to six carpels, with as many parietal placentas, and is closed at the top, or open during the whole or the greater part of its growth, as in Reseda, or gaping as in Caylusea. The ovules are numerous as in Reseda or one to two as in Astrocarpus. The latter is remarkable in the mature state when its four to six carpels divaricate in a stellate manner, each containing one seed only. The ovules are amphitropous or campylotropous, and inserted on the walls of the ovary or near the base of the cavity. The seeds are numerous, or few in Astrocarpus and Caylusea, and two to three in Randonia; they are reniform with a smooth testa or rough in Randonia, and are usually exalbuminous, but exceptions occur as in the Capparideæ. The fruit is capsular, follicular (Astrocarpus), or baccate (Ochradenus).

The embryo is large and curved or complicated, filling the interior of the seed. The cotyledons are incumbent, and in Reseda they constitute the greater part of the embryo, the radicle being extremely short. Caylusea abyssinica (fig. 184) forms an exception, inasmuch as an appreciable quantity of endosperm surrounds the large embryo, while in the sinus between the cotyledons and radicle lies a considerable thickness of it.

The seeds are reniform and slightly compressed laterally; and the cotyledons of the large embryo lie in the narrow plane of the seed, with their tips curved round to the hilum, but their backs to the placental axis. They are plano-convex and taken together are much thicker and wider than the terete or cylindrical radicle, which is about equal to the cotyledons in length.

Cotyledons.—The cotyledons of Reseda are broad and ovate in R. luteola, oblong or oval in R. odorata, and spathulate in R. alba (fig. 185). Those of the first named are somewhat succulent, taper into the petiole, have a few ascending veins on each side of the midrib, and are sometimes unequal in shape and size. The cotyledons in the other cases are also somewhat succulent with a faint midrib, but no other discernible venation in the fresh state. The embryo of Caylusea while in the seed is similar to that of Reseda in general outline.

Caylusea abyssinica, *Fisch. et Mey.* (fig. 184).

Seed almost orbicular, with a prominent basal notch, 1–1·25 mm. in diameter; testa crustaceous, brown at first, then bright shining black, smooth.

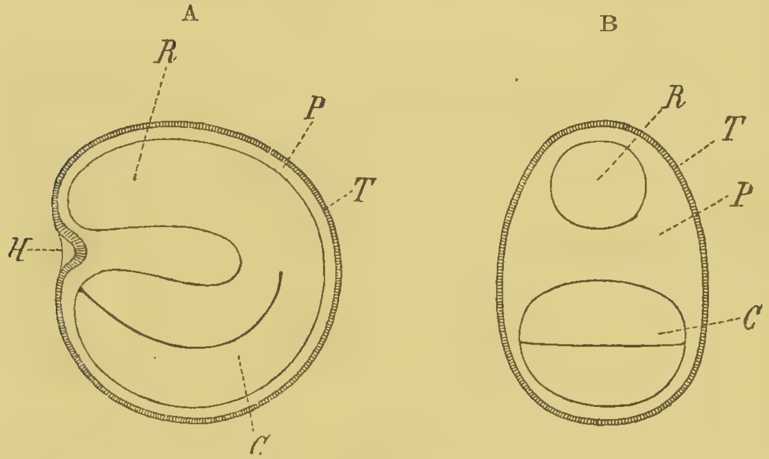

Fig. 184.—*Caylusea abyssinica.* A, longitudinal section of seed. B, transverse section, both × 30: *P*, endosperm; *C*, cotyledon; *T*, testa; *R*, radicle; *H*, hilum.

Endosperm comparatively copious, surrounding the embryo, greyish-white.

Embryo curved or rounded on itself, surrounded by endosperm, colourless; cotyledons oval, entire, fleshy, plano-convex, sessile, with their edges towards the basal notch; radicle terete, obtuse, superior, about the same length as the cotyledons.

Reseda alba, *L.* (fig. 185).

Primary root slender, tapering, fibrous.

Hypocotyl terete, elongated, pale green or colourless, glabrous, about 12–15 mm. long.

Cotyledons spathulate, obtuse, entire, petiolate, glabrous, light green, tapering into the petiole, about 17 mm. long including the petiole, one-nerved; petiole channelled above, dilated at the base and subperfoliate.

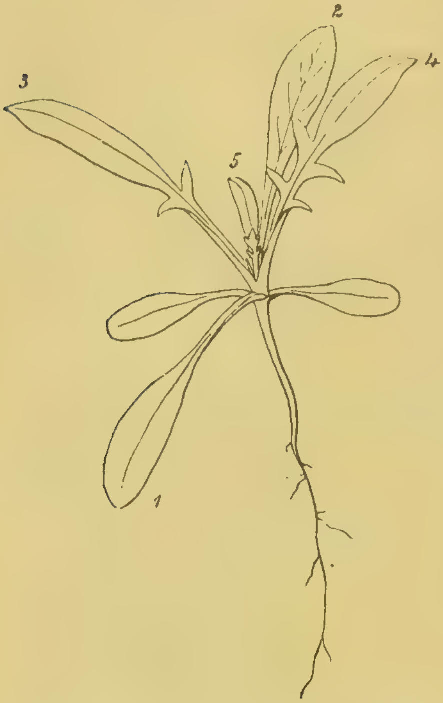

FIG. 185.—*Reseda alba.* Nat. size.

Stem herbaceous and developed when about to flower.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, entire, glabrous, slightly scabrous at the margin, light green, indistinctly alternately and ascendingly penninerved and reticulate towards the margins; petioles slightly channelled above, dilated and clasping at the base; stipules small, glandular, tooth-like and projecting from the upper edges of the petioles a little above their base.

Nos. 1 and 2. Spathulate, obtuse, entire, with a few ascending nerves and reticulate towards the margin.

No. 3. Oblong, with two small lateral, subulate, acute lobes near the base, and a nerve running into each lobe; middle lobe oblong, entire.

No. 4. Oblong, pinnatifid, with two alternate, subulate, acute lobes on each side, with branches running into them from the midrib; middle lobe oblong-lanceolate, entire.

Ultimate leaves pinnatisect with linear more or less undulate segments, glaucous or green, glabrous.

Reseda luteola, *L.*

Primary root as in R. alba.

Hypocotyl decumbent, or more often erect, tapering slightly downwards, 4–8 mm. long.

Cotyledons ovate or oblong-ovate, somewhat succulent, sometimes unequal in size and shape; lamina 6–8 mm. long, 4·75–5·5 mm. wide; petiole rounded on the back, flattened or shallowly grooved above, 5–6·5 mm. long.

Stem as in R. alba, annual or biennial.

Leaves as in R. alba, but stipules small, glanduliform, seated on the petiole some distance above the base, and often at unequal heights.

Nos. 1 and 2. Spathulate, obtuse, tapering to the base, alternately and ascendingly nerved.

Nos. 3–6. Similar.

Ultimate leaves linear, entire, obtuse, undulate at the margin, alternately incurvinerved, deep green, glabrous, shining, with a prominent midrib; the radical narrowed to a short, flattened, more or less winged petiole, the cauline sessile.

Reseda odorata, *L.*

Primary root long, wiry, tapering, with very few or no lateral rootlets for some distance.

Hypocotyl subterranean, stout, tapering downwards indistinguishably into the root.

Cotyledons oblong; lamina 9 mm. long, 5 mm. broad; petiole 4·5 mm. long.

Stem herbaceous, erect, or ultimately decumbent, glabrous, green, slightly angled and furrowed, with lines of scattered, filiform, glandular appendages running down from the base of the leaves; 1st internode 1 mm. long; 2nd 2·25 mm.; 3rd 7 mm.; 4th 1 mm.; 5th 13 mm.; 6th 9 mm.; 7th 5·5 mm.

Leaves cauline, alternate (or first four opposite in two pairs), petiolate, or the uppermost sessile or subsessile, flat or subrevolute at the margin, alternately penninerved, glabrous, scabrous at the margin; petioles channelled above on either side of a prominent midrib, convex beneath; stipules consisting of filiform glandular processes extending from the base of the petiole for some distance down the stem.

1st pair opposite, spathulate, entire.

2nd pair opposite, oblong-spathulate, entire.

Nos. 5–6. Nearly opposite (in specimen), linear-oblong, obtuse, entire.

Nos. 7–10. Oblong-spathulate, obtuse, entire.

Upper cauline leaves oblong, obtuse, entire or trifid or tripartite; segments oblong, obtuse, entire; lateral ones much broader on the posterior side of the midrib and decurrent on the petiole.

CISTINEÆ.

Benth. et Hook. *Gen. Pl.* i. 112.

The ovary in this Order is free, consisting of three to five carpels united by their edges only, and is one- or partly three- to five-celled by the prominence or inflection of the three to five parietal placentas. The ovules are generally numerous on each placenta, but there are only two in Hudsonia and Lechea; ascending and projecting into the cavity of the ovary on long or rarely short funicles, and orthotropous, rarely semianatropous as in Lechea and Fumana by the funicles being partly adnate to the placenta. Orthotropous ovules are generally associated with one-seeded fruits as in Polygonaceæ, many Urticaceæ, and Juglandaceæ, so that Cistus and Helianthemum are very exceptional in possessing orthotropous ovules in a many-seeded ovary. The fruit is a capsule dehiscing by as many valves as there are carpels. The dehiscence being loculicidal, the seeds are borne along the centre of the valves as in the Violarieæ to which the Cistineæ are allied. The seeds are numerous in the two leading genera, Cistus and Helianthemum, and are ovoid or variously angled by mutual pressure. They contain a large quantity of a farinaceous or mealy endosperm, sometimes occupying one side of the seed only as in Cistus laurifolius, or in some cases almost equally distributed and completely surrounding the embryo. The latter is therefore generally excentric, and curved, spirally convolute, or conduplicate, rarely nearly straight as in Lechea. The cotyledons are plano-convex, nearly flat or narrow, and semiterete.

Cistus laurifolius, which may be taken as typical of the group, has a spirally coiled, excentric, comparatively large embryo, with linear, obtuse, semiterete, incumbent cotyledons lying in the narrow plane of the somewhat flattened seed, with their backs to the placenta. The cotyledons are equal, the inner one in this case at least being more coiled than the outer. The embryo of C. villosus seems to be more central than usual, and the cotyledons are linear-oblong, incumbent, and shorter than the radicle. The embryo of Helianthemum, according to Bentham and Hooker, is uncinate, biplicate, or circumflexed.

Those coming under my notice are spirally coiled much in the same way as in Cistus, but the cotyledons are usually broader and lie in the broader plane of the seed when that is flattened in any way. There are a few slight modifications. They are incumbent as usual, but the radicle in H. Spachii and H. violaceum is displaced at its upper end and lies obliquely over the edges of the cotyledons. This is carried further in H. polifolium, and the broadly oval cotyledons are almost strictly accumbent, lying in the broader plane of the seed with their edges to the hilum. The radicle, as in all the other species examined, is longer than the cotyledons, in some instances about twice as long.

Cotyledons.—There are two leading types of cotyledons represented by the two leading genera, Cistus and Helianthemum; in the former they are comparatively narrow, in the latter broad. Taking Cistus laurifolius (fig. 186) as an illustration, the cotyledons are linear-lanceolate, obtuse or subacute, entire, flat or convex above, and subrevolute at the margins, dotted with minute scales on both surfaces, otherwise glabrous, deep green, opaque, with an indistinct midrib, narrowed at the base or shortly petiolate, and connate forming a little cup surrounding the plumule. The seed-leaves of C. undulatus, C. ladaniferus, and C. albidus agree closely in all the leading characters with the above, except that in C. undulatus they are less distinctly petiolate. It may also be noted that the hypocotyl of the latter is finely pubescent, as are both the hypocotyl and petioles of the cotyledons in C. albidus.

The broad type of cotyledons may be represented by Helianthemum vulgare or H. apenninum (fig. 187). They are broadly oblong or obovate in the latter, distinctly petiolate, entire, trinerved in the basal half, but indistinctly so upwards, with the lateral nerves running parallel to the margin, deep green, and glabrous with the exception of the petioles, which are thinly hairy. The hypocotyl is also pubescent. The cotyledons of H. vulgare are broadly oval or subobovate, and one-nerved, but otherwise correspond closely to those of H. apenninum. The lateral veins probably exist, although indiscernible owing to the opaque character of the cotyledons. These are oval-oblong, very large and one-nerved, with hairy petioles shortly connate at the base in H. rosmarinifolium, and form a contrast to the narrow leaves of the species. In germination the testa in Cistus and Helianthemum splits widely to allow the exit of the cotyledons.

Cistus laurifolius, *L.*

Fruit a one-celled, many-seeded, loculicidal capsule.

Seeds numerous, on the parietal placentas, polygonal, pale brown, glabrous, on a long funicle; hilum at the basal end; raphe none; chalaza rather prominent and projecting into the interior of the seed.

Endosperm granular or subfarinaceous, extending from the base up one side of the seed.

Embryo spirally coiled, eccentric, pale yellow, very large for the seed; cotyledons linear, obtuse, entire, equal, the inner one being much more coiled than the outer, situated with their backs to the placenta, and their edges towards the sides of the seed, plano-convex, or semiterete; radicle cylindrical, obtuse, stout, somewhat shorter and narrower than the cotyledons.

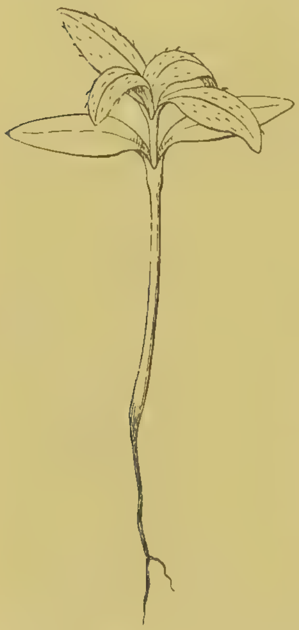

Fig. 186.—*Cistus laurifolius*, × 2.

Seedling (fig. 186).

Hypocotyl erect, terete, glabrous, 13–18 mm. long.

Cotyledons linear-lanceolate, obtuse or subacute, entire, flat or convex above, and subrevolute at the margins, dotted with minute scales on both surfaces, otherwise glabrous, deep green, opaque, with an indistinct midrib, narrowed to the base and perfoliate, forming a little cup round the plumule, 6·5–8 mm. long, 1·75–2·25 mm. broad.

Stem erect, terete, stellately hairy, pale green, ultimately shrubby; 1st internode 2·5–6·5 mm. long.

First leaves simple, entire, cauline, opposite, decussate, exstipulate, petiolate, with a few hairs on both surfaces, alternately and ascendingly penninerved; petioles very short, channelled above, perfoliate or connate at the base forming a little cup.

1st pair small, lanceolate, obtuse, entire, subtrinerved at the base, otherwise alternately penninerved.

2nd pair similar.

Cistus undulatus, *Dunal.*

Hypocotyl 12–18 mm. long, finely pubescent, reddish.

Cotyledons linear-lanceolate, acute, tapering at the base but scarcely petiolate, entire, glabrous, light green, indistinctly one-veined.

Stem herbaceous, pubescent; 1st internode 1–2 mm. long, light green.

First leaves entire, linear-lanceolate, acute, tapering to the base, sessile, pubescent, light green, one-veined.

Cistus ladaniferus, *L.*

Hypocotyl glabrous, 5–8 mm. long, reddish.

Cotyledons linear, subacute, otherwise as in C. undulatus.

Stem as in C. undulatus.

First leaves linear-oblong, shortly petiolate, slightly hairy, green, distinctly one-veined.

Cistus albidus, *L.*

Hypocotyl finely pubescent, 5–10 mm. long, stained with red.

Cotyledons obtuse, glabrous with a few hairs towards the base, dark green, otherwise as in C. undulatus.

Stem as in C. undulatus.

First leaves oblong, obtuse, tapering to the base, ciliated, finely pubescent, dark green, pinnatinerved.

Helianthemum apenninum, *DC.* (fig. 187).

Hypocotyl erect, terete, pubescent, 1·5–2 cm. long, reddish immediately above the ground, becoming light green near the cotyledons.

Cotyledons oblong or slightly obovate, 4–5 mm. long, petiolate, entire, obtuse, glabrous but with a few hairs on the petiole, dark green tinged with red beneath; midrib and two indistinct lateral veins running parallel to the edges conspicuous in the basal half.

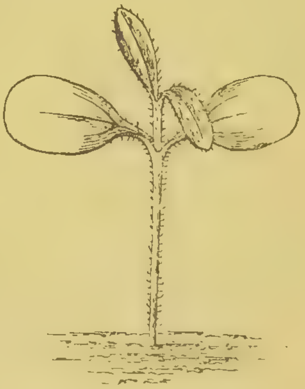

Fig. 187.—*Helianthemum apenninum*, × 2.

Stem herbaceous, erect, terete, pubescent.

First leaves simple, entire, cauline, opposite, stipulate, lanceolate, obtuse, pubescent, light green, with a prominent midrib.

Helianthemum vulgare, *Gaertn.*

Primary root long, tapering, with fleshy, stout, lateral rootlets, generally stouter than the primary one.

Hypocotyl erect, terete, hairy, reddish, sometimes decumbent (perhaps accidental) at the base.

Cotyledons broadly oval or subobovate-oval, rounded and obtuse at both ends, opaque green, one-nerved; lamina 4·5–5·5 mm. long, 3–4·5 mm. broad; petiole subterete, slightly channelled above, hairy, reddish, about 2 mm. long.

Stem shrubby, erect, ultimately decumbent, wiry, hairy or glabrous, but reddish and hairy in seedling stage; 1st internode 3 mm. long.

Leaves shortly petiolate, subperfoliate at the base, more or less hairy on both surfaces and margin when young with bulbous-rooted hairs, ultimately glabrous or hairy in different varieties; petioles subterete, narrowly channelled above, glabrous, or hairy at least when young; stipules lanceolate, obtuse, slightly hairy, ultimately linear-lanceolate, acute, deep green, shining, hairy or glabrous, according to the leaves.

1st pair lanceolate, obtuse, channelled along the middle of the upper surface, with a prominent midrib.

Ultimate leaves oblong, obtuse or obtusely subcuspidate, more or less revolute at the margin, with a strong midrib, sunk on the upper surface and prominent beneath, deep green, and shining above when devoid of hairs, paler beneath; but when hairy they are greyish above, and more or less hoary or white beneath.

Helianthemum rosmarinifolium, *Pursh.*

Cotyledons large, oval-oblong, obtuse, deep green above, red beneath, glabrous except the petiole; lamina with a faint midrib, 6–7 mm. long, 3·5–4·5 mm. wide; petiole hairy, slightly channelled above, 2–3 mm. long, shortly connate at the base.

Stem ultimately shrubby; 1st internode gradually developing to a length of 1, 2, or 3 mm.

Leaves linear, with stellate hairs, at least in the young state, deeply channelled above, carinate beneath and revolute at the margins.

VIOLARIEÆ.

Benth. et Hook. *Gen. Pl.* i. 114.

Fruit and Seed.—The ovary is free and one-celled with typically three parietal placentas as in Viola. The ovules are generally numerous, one to two as in Hymenanthera, Scyphellandra, and Isodendrion, anatropous and arranged along the slender placentas. The fruit is a capsule and splits loculicidally, more rarely septicidally, by as many valves as there are carpels. In Leonia, Gloiospermum, Tetrathylacium, Melicytus, and Hymenanthera it is however baccate and indehiscent. The seeds are obovoid or subglobose and fixed to the placentas by very short funicles; the raphe is in some cases much thickened and separates from the fruit when mature, forming an arillus; the testa is usually crustaceous, coriaceous, and shining as in Viola itself, rarely membranous. The endosperm is copious and fleshy except in the case of Corynostylis, where it is reduced to a thin layer. The embryo as far as observed is straight, central, somewhat club-shaped, nearly equalling the endosperm in length; the cotyledons are plano-convex or flat, and generally moderately broad, longer or shorter than the radicle and distant from the hilum. They are unusually narrow in the species of Hymenanthera and very short in the Sauvagesieæ.

Viola tricolor and V. sylvatica may be taken as typical of the Order. They have obovoid, smooth seeds; and the cotyledons of the latter before germination are oval, obtuse, entire, plano-convex, and about the same length as the terete, obtuse radicle.

Variations from the type occur in Corynostylis, with flattened, rugose, nearly orbicular seeds; they are flattened, orbicular, and broadly winged in Anchietea; flattened, winged, and imbricate in Agation; and small with an orbicular wing and a membranous testa in Schuurmansia. They are globose or nearly so in Paypayrola, Alsodeia, Leonia, Melicytus, Tetrathylacium, Hymenanthera, and Scyphellandra.

Several methods of dispersal of the seeds occur in this Order. As already mentioned, some have winged seeds. I have observed that ants sometimes carry the seeds of Viola into their nests, and I am inclined to suspect that they mistake them for the pupæ of other ants.

Some Violets throw their seeds. In the Dog Violet (V. canina) the capsules, though pendent when young, at maturity raise themselves[1] above the rest of the plant, and open by three equal valves resembling an inverted tripod.[2] Each valve contains a row of three, four, or five brown, smooth, pear-shaped seeds, slightly flattened at the upper, wider, end. The two walls of each valve, as they become drier, contract, and approach one another, thus tending to squeeze out the seeds. These resist some time, but at length the attachment of the seed to its base gives way, and it is ejected several feet, this being no doubt much facilitated by its form and smoothness. I have known even a gathered specimen throw a seed nearly ten feet.

On the other hand, in Viola hirta the capsules hang down, and it has been said actually bury themselves in the ground. 'Now we naturally ask ourselves[1] what is the reason for this difference between the species of Violets; why do V. odorata and V. hirta conceal their capsules among the moss and leaves on the ground while V. canina and others erect theirs and throw the seeds to a distance? If this arrangement be best for Viola canina, why has not V. odorata also adopted it? The reason is, I believe, to be found in the different mode of growth of these two species. V. canina is a plant with an elongated stem, and it is easy therefore for the capsule to raise itself above the grass and other low herbage among which Violets grow.

'V. odorata and V. hirta, on the contrary, have in ordinary parlance no stem, and the leaves are radical, *i.e.* rising from the root. This is at least the case in appearance, for, botanically speaking, they rise at the end of a short stem. Now under these circumstances if the Sweet Violet attempted to shoot its seeds, the capsules not being sufficiently elevated, the seeds would merely strike against some neighbouring leaf, and immediately fall to the ground. Hence, I think, we see that the arrangement of the capsule in each species is that most suitable to the general habit of the plant.'

Cotyledons.—The only seedlings I have seen of this Order belong to the genus Viola. The cotyledons of V. tricolor (fig. 188) are broadly oval, obtuse, entire, and petiolate. The lamina is proportionately longer and narrower in V. canina, and V. palustris (fig. 189), where it is oblong, obtuse, and in the latter mucronulate. The variations from these types are probably slight except in the cases of narrow or short cotyledons as mentioned above.

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[1] Lubbock's *Flowers, Fruits, and Leaves*, p. 55 (fig. 38 c).

[2] *Ibid.* p. 56.

Viola tricolor, *L.* (fig. 188).

Primary root tapering, colourless, long, giving off lateral rootlets, annual.

Hypocotyl tapering indistinguishably into the root, subterranean, colourless.

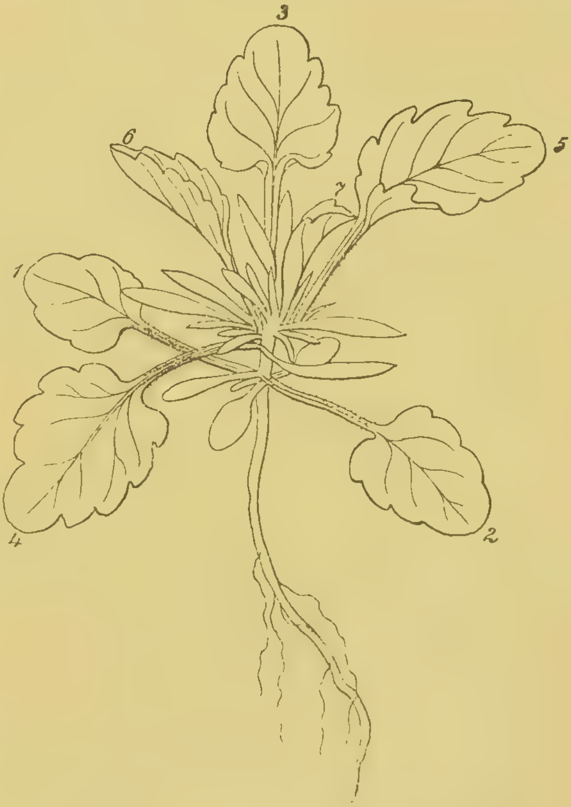

Fig. 188.—*Viola tricolor.* Nat. size.

Cotyledons oval, obtuse, glabrous, petiolate; lamina 6 mm. long, 3·5 mm. broad.

Stem developed when about to flower, herbaceous, annual; 1st, 2nd, and 3rd internodes undeveloped; 4th 1·5 mm. long; 5th 1 mm. long.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, glabrous, or finely pubescent at the margins, deep green above, paler beneath; petioles channelled on the upper side, and scaberulous, or finely pubescent, along the edge of the channel; stipules large, foliaceous, unequally lyrate-pinnatifid or -partite, with linear, obtuse, or oblanceolate-linear segments—the middle lobe largest and entire, or in adult and robust specimens more or less crenate and spathulate.

No. 1. Broadly ovate, rounded at the end, shallowly crenate.

No. 2. Cordate-ovate, obtuse, shallowly crenate.

No. 3. Oblong-cordate, obtuse, more deeply crenate.
No. 4. Cordate, obtuse, rather deeply crenate.
No. 5. A little more elongated than No. 4.
No. 6. Cordate-ovate, rather deeply crenate.

Ultimate leaves oblong-lanceolate, obtuse, serrate-crenate, or the uppermost lanceolate, elongated and narrowed to an obtuse point, with long ascending lateral veins; stipules foliaceous, very large, pinnately divided near the base, with the greatest number of lobes on the posterior side and almost surrounding the stem.

Viola palustris, *L.* (fig. 189).

Primary root as in V. tricolor.

Hypocotyl as in V. tricolor.

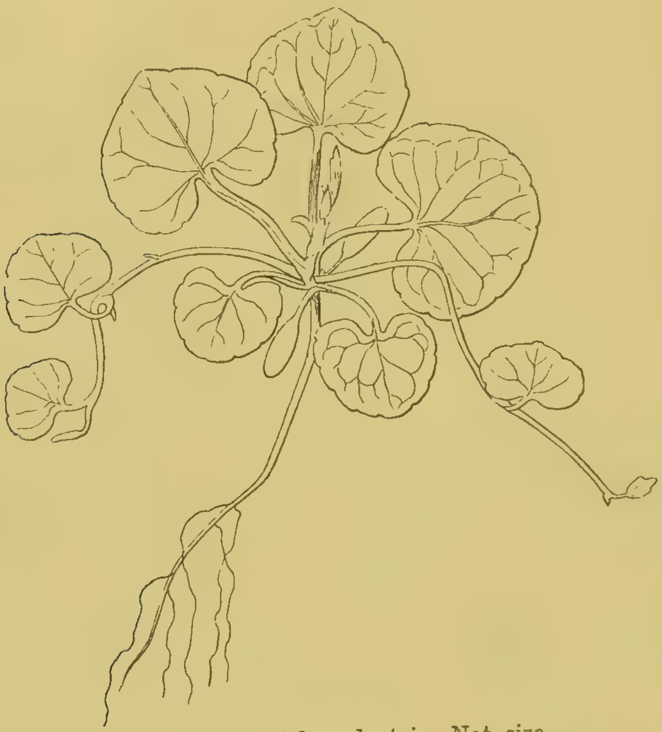

Fig. 189.—*Viola palustris*. Nat. size.

Cotyledons oblong, obtuse, mucronulate, glabrous; lamina 6 mm. long, 3·5 mm. broad; petiole channelled above, 3·5 mm. long.

Stem herbaceous, perennial, with undeveloped nodes, and throwing off numerous stoloniferous branches from the axil of the first leaf, upwards.

Leaves radical and cauline on the stolons, conspicuously nerved and reticulate; stipules small, ovate, serrulate, green, mottled with red; petioles channelled above, glabrous, pale green, mottled with red.

Nos. 1–3. Reniform, rounded at the apex, three- to five-nerved, shallowly crenate.

Nos. 4 and 5. Reniform, obtusely angled at the apex; five-nerved on the lower half, shallowly crenate.

Ultimate leaves rather large, reniform, rounded at the apex, shallowly crenate, seven- to nine-nerved and reticulate.

CANELLACEÆ.

Benth. et Hook. *Gen. Pl.* i. 121.

Fruit and Seed.—The ovary is free, one-celled, with two to five parietal placentas, and contains from two to many ascending or horizontal ovules that are nearly but not quite anatropous. The fruit is indehiscent and a berry, and as is frequent in such cases the testa of the seed is hard or crustaceous, smooth and shining. Each berry contains from two to many seeds according to the species. The embryo is large, straight, or slightly curved with oblong cotyledons and a short radicle situated close to the hilum, and is embedded in a fleshy, oily endosperm.

No seedlings have come under my observation.

BIXINEÆ.

Benth. et Hook. *Gen. Pl.* i. 122.

Fruit and Seed.—The ovary is superior, syncarpous, and made up of from two to many carpels with as many parietal placentas, one-, rarely many-celled, as in Flacourtia and Amoreuxia. The ovules are amphitropous or anatropous, rarely one, seldom two, generally many on each placenta; Aphloia is exceptional in having only one placenta and few ovules. The fruit is dry and capsular or baccate and indehiscent. Sometimes it is spiny resembling that of Æsculus or some species of Datura, as is the case with Bixa and Dendrostylis.

The seeds are usually globose or obovoid; but there are exceptions, the most remarkable of which occurs in Cochlospermum, the species of which have reniform or spiral seeds covered with long hairs or woolly on all sides; the testa itself is horny. In most cases, however, the seeds are smooth, while in Bixa and Dendrostylis they are covered with an aril or pulp. The interior is filled with a copious, fleshy endosperm surrounding the embryo. The seeds are arillate in Ryania and Lætia, and furnished with an arilloid membranous coat in Erythrospermum. They are more or less compressed in Bixa and Oncoba. Those of Aberia are densely covered with a villous tomentum.

The embryo is axile and straight or curved according to the form of the seed, to which it conforms to a certain degree, being curved in the curved seeds of Aphloia, and longitudinally grooved in Bixa, apparently owing to the raphe being deeply sunk in the side of the seed. This is best observed in transverse section. The embryo is always comparatively large and nearly equals the endosperm both in length and breadth, but not in thickness, and the cotyledons are flat, and more or less cordate. The seeds of Pangium edule are bluntly triangular vertically, and in longitudinal section the embryo is also seen to be of great size with bluntly triangular cotyledons, traversed longitudinally by five to seven diverging nerves. They are faintly notched or subcordate at the base; and the radicle is extremely short.

Cochlospermum Gossypium, *DC.* (fig. 190).

Hypocotyl erect, stout, subfleshy, glabrous, pale green, about 12–16 mm. above the soil.

Cotyledons linear-oblong, obtuse or subacute, glabrous, petiolate, seven- to eleven-nerved from the base or near it, slightly unequal; lamina of the larger one about 4·7 cm. long, 1·05 cm. wide; of the shorter one 4·5 cm. long, and 1·05 cm. wide; petioles channelled above, connate at the base, slightly scurfy with brown scales or glands, 10–11 mm. long.

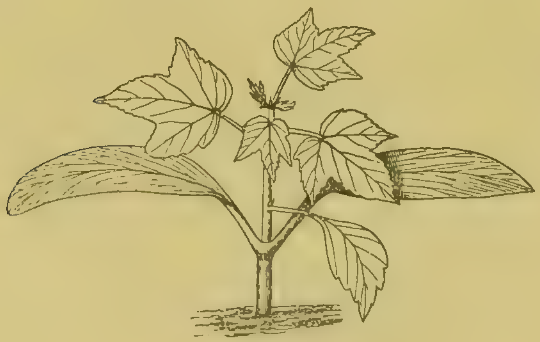
Fig. 190.—*Cochlospermum Gossypium.* Half nat. size.

Stem erect, terete, glandular - scurfy and slightly pubescent, much thinner in the seedling stage than the hypocotyl; 1st internode 6 mm. long; 2nd 10 mm.; 3rd 3 mm., and the next two or three also short.

Leaves simple, cauline, alternate, stipulate, petiolate, palmately-nerved and lobed, thinly glandular-scurfy along the nerves on both surfaces; petioles subterete, slightly channelled on the upper surface, glandular-scurfy; stipules small, subulate, acute, soon becoming brown.

No. 1. Ovate or subelliptic, coarsely serrated above the middle or subtrifid with alternate ascending nerves.

Nos. 2–4. Palmately five-nerved and trilobed, or the 3rd and 4th slightly five-lobed; lobes triangular, obtuse, and rounded or acuminate and subacute, crenate-serrate, with the terminal lobe the largest.

No. 5. With more elongated and more ovate leaves, otherwise similar.

NOTE.—The seed of Cochlospermum is cochleate-reniform or spiral. The embryo is incurved and the cotyledons ovate while still in the seed, which would account for their unusually elongated character after germination. The cotyledons of other members of the Order coming under my notice are short and very broad or rounded.

Aberia caffra, *Hook. et Meyer* (fig. 191).

Hypocotyl erect, terete, minutely pubescent, pale green, 2·5–3·5 cm. long.

Cotyledons broad, almost rotund-obovate, foliaceous, petiolate, glabrous, entire or incipiently emarginate, alternately and incurvedly penninerved (each nerve uniting with the one next above it), reticulate, bright shining green above, paler beneath; petiole slightly channelled above, minutely pubescent, subperfoliate at the base, 2·5–3 mm. long; lamina 2·2–2·5 cm. long, 1·8–2 cm. wide.

Stem erect, terete, finely pubescent, pale green, ultimately shrubby; 1st internode 4–5 mm. long.

Leaves simple, cauline, alternate (1st and 2nd opposite), stipulate, petiolate, alternately penninerved, with each nerve ascending at an acute angle, and uniting with the one next above it, hairy on both sides, light green; petioles very short, flattened above, hairy; stipules minute, tooth-like at the base of the petioles.

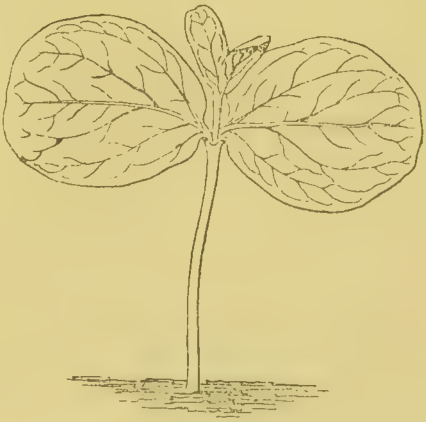

FIG. 191.—*Aberia caffra.* Nat. size.

Nos. 1 and 2. Oblanceolate-oblong, tapering to the base, emarginate, with a small tooth or mucro in the notch.

PITTOSPOREÆ.

Benth. et Hook. *Gen. Pl.* i. 130.

Fruit and Seed.—The ovary is free, syncarpous, consisting of two carpels, more rarely of three to five, and is one-celled with parietal placentas, or the placentas are sometimes so much intruded as to form septa. The ovules are numerous, horizontal, anatropous. The fruit is dry and dehisces loculicidally, while the valves sometimes break away from the dissepiments, or baccate and indehiscent. The seeds are numerous, rarely few or solitary in the cells, and filled with a copious hard endosperm. The testa is thin and smooth, rarely rugose-muricate and often black. The embryo is very minute and embedded in the endosperm close to the hilum.

The embryo in Pittosporum undulatum is a minute nodular mass with hardly discernible cotyledons situated or embedded in the endosperm at the base of the reniform seed near a notch or depression at the hilum. As far as form is concerned it cannot be much influenced by the shape of the seed before germination. The seeds of Hymenosporum are flattened, reniform, and girt with a membranous wing.

Cotyledons.—As in the case of the seed-leaves in other Orders having a copious endosperm, whether the embryo is large or small while yet in the seed, the cotyledons after germination attain a considerable size. They vary from linear to linear-lanceolate, lanceolate, or oblanceolate. The broader ones are characteristic of Pittosporum, the type of the Order. In P. phillyræoides (fig. 192) they are linear-lanceolate, acute, sessile or narrowed to a very short petiole, hairy on the midrib beneath, the midrib only being discernible. They are rather persistent and with the exception of the venation resemble very closely the first six leaves.

The other two species observed are very exceptional and somewhat remarkable in character. The cotyledons of P. crassifolium are four in number, oblanceolate, narrowed to a short petiole, mucronate, rather unequal and apparently consisting of two divided to the base, pubescent on both surfaces, ciliate, rather persistent, with a sunk midrib and obscurely reticulate, and resemble in form the leaves that follow, but are very much smaller. Those of P. erioloma are five in number, whorled, lanceolate, membranous, shortly petiolate, pubescent and penninerved like the leaves that follow, but larger.

A type distinct from the above is exhibited by Billardiera longiflora and B. fusiformis. In the former (fig. 194) the cotyledons are linear, acute, broadest above the middle, narrowed to the base, but not very distinctly petiolate, with a scarcely discernible midrib, glabrous, and 12·5–22 mm. long. The seed-leaves of B. fusiformis are linear, acute, glabrous, one-veined, sessile, and about the same length as those of B. longiflora.

Pittosporum phillyræoides, *DC.* (fig. 192).

Hypocotyl erect, terete, glandular-pubescent, deep red, 3–4·5 cm. above the soil.

Cotyledons linear-lanceolate, acute, sessile or narrowed to an extremely short petiole, light green, pubescent on the midrib beneath, otherwise glabrous, slightly channelled at the base on the upper side, and subcarinate on the under side, with midrib only discernible, about 24 mm. long, 4–5 mm. wide.

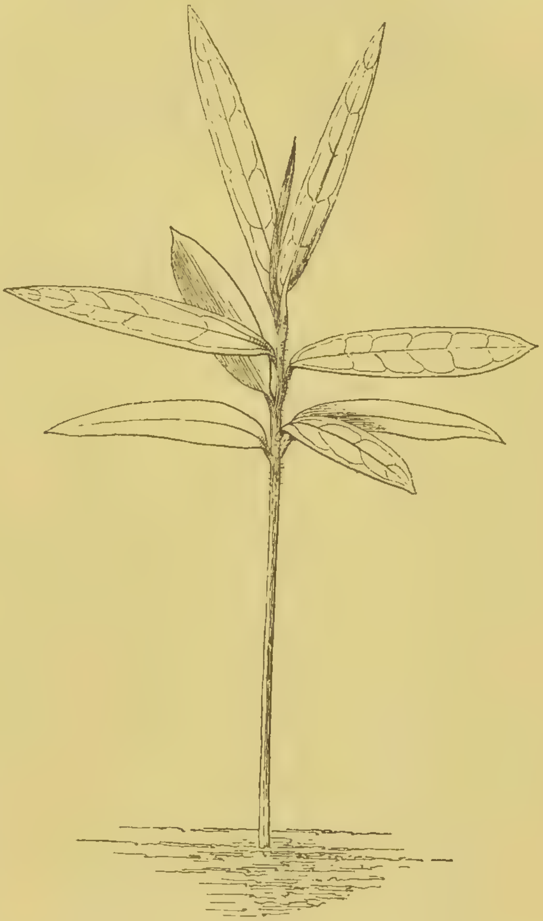

FIG. 192.—*Pittosporum phillyræoides.* Nat. size.

Stem erect, terete, pubescent with adpressed hairs, deep red, somewhat flexuous; 1st internode 1·5 mm. long; 2nd 2 mm.; 3rd 3·25 mm.

Leaves simple, entire, cauline, alternate, exstipulate, shortly petiolate, alternately penninerved, with the nerves uniting at their apex and forming a continuous intramarginal line, glabrous, coriaceous, deep green above, pale beneath, shining on both surfaces; petioles short, channelled above, terete on the back.

No. 1. Lanceolate-oblong, cuspidately acute.

No. 2. Similar, larger.

Nos. 3–6. Lanceolate-linear, acute, or acuminate, gradually longer.

Pittosporum parviflorum, *Putterl.*

Hypocotyl glabrous.

Cotyledons two to three, lanceolate, obtuse, glabrous, shortly petiolate, obscurely penninerved, reticulate, foliaceous, rather persistent.

Stem terete, erect, soon becoming woody.

First three leaves obovate-lanceolate, entire, small, cuneate at the base.

Pittosporum crassifolium (?), *Banks et Sol.* (fig. 193).

Hypocotyl 3–4 cm. long, a little over 1 mm. thick, woody, covered to the very base with a purplish pubescence (like Gynura aurantiaca).

Cotyledons two, three, or four, opposite or whorled, nearly equal, shortly petioled, 1·5–2 cm. long, about 1 cm. broad, nearly flat, oblanceolate, produced at the base, with a short blunt mucro at the obtuse, slightly recurved apex, penninerved, with sunk midrib and obscurely reticulate veins, hairy on both sides, ciliated on margin and petiole, light green, rather persistent.

Stem like the hypocotyl, but darker and tomentose.

Leaves penninerved with the branches ascending, branching or incurved towards the tip, reticulate, with the principal nerves sunk on the upper surface, glabrous above, pubescent or tomentose on the margin, tomentose beneath with a prominent venation; petioles short, semiterete.

Nos. 1 and 2. Rotund-obovate, cuneate at the base.

Nos. 3 and 4. Obovate, obtuse, gradually becoming larger upwards.

Note.—I was at first disposed to think that the number of cotyledons in this species might be an accidental variation. There are other cases where occasionally three cotyledons occur instead of two. In Acer Pseudo-Platanus, for instance, this is not infrequently the case, and I have observed that such specimens occur especially often in the produce of particular trees.

Pittosporum erioloma, *Moore et F. Muell.*

A seedling of this species also had five lanceolate, subacute, entire, pubescent, nearly sessile cotyledons.

Billardiera longiflora, *Labill.* (fig. 194).

Hypocotyl erect, terete, glabrous, brownish-purple, shining, 14–27 mm. above the soil.

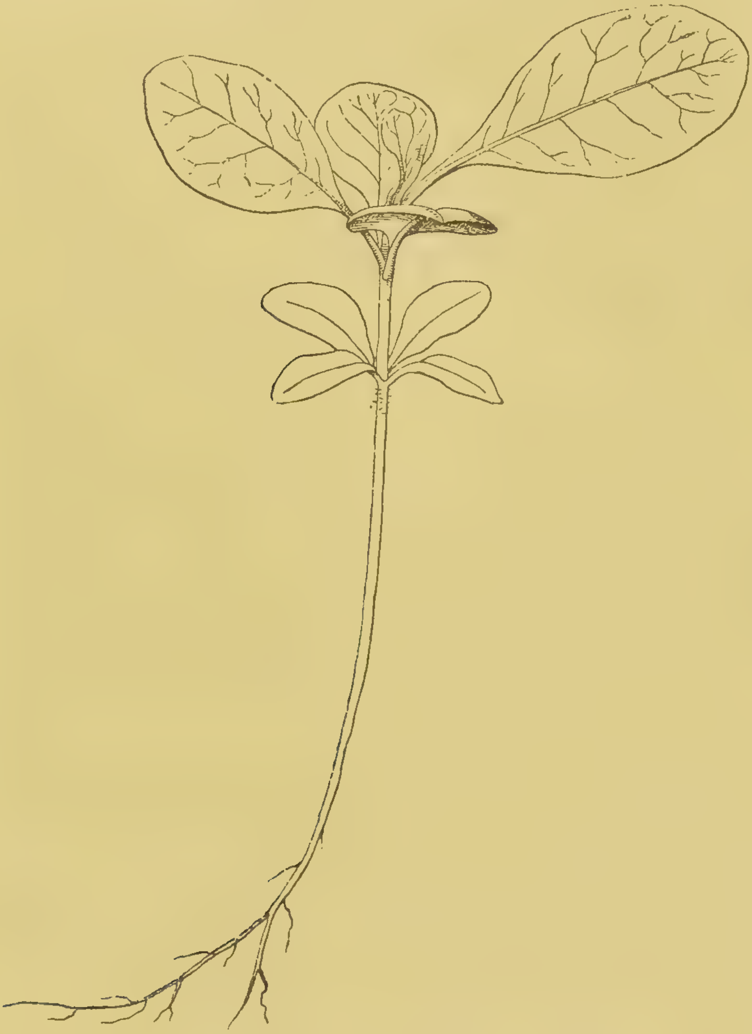

FIG. 193.—*Pittosporum crassifolium.* Nat. size.

Cotyledons linear, acute, or cuspidate, broader above the middle, narrowed to a slender, petiole-like base, deep green and shining above, with a scarcely discernible midrib, paler beneath, 12·5–22 mm. long, ·75–2 mm. wide at the broadest part.

Stem erect, terete, somewhat flexuose (at least when young), pale green or soon becoming brownish-purple, pubescent, with hooked, bent, or branched hairs, ultimately shrubby, twining; 1st internode and frequently the 2nd undeveloped; 2nd when developed 1–2 mm. long; 3rd 3·5–4·5 mm.; 4th 2–3 mm.

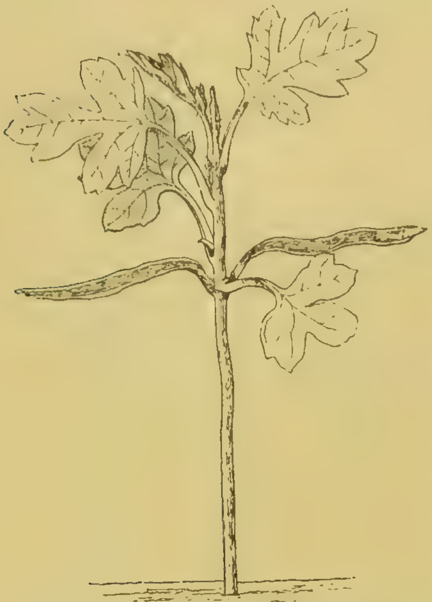

Fig. 194.—*Billardiera longiflora.* One-sixth over nat. size.

Leaves simple, cauline, alternate (first and second often opposite), exstipulate, petiolate, alternately penninerved, with the nerves running straight into the lobes or teeth, somewhat pubescent on the margins and nerves, especially when young, with bent, kneed, or forked hairs, deep green and shining above, pale beneath; petioles channelled above, convex on the back, slightly pubescent, deep green.

Nos. 1 and 2. Triangular, trilobed; lateral lobes cuneate, bidentate; middle lobe entire or tricuspidate. In very small weak seedlings the first two leaves are frequently merely cuneate, tricuspidate.

Nos. 3 and 4. Triangular-ovate, trilobed, longer and larger than the first two; middle lobe trifid or coarsely serrate; lateral lobes bifid or serrate, mostly on the posterior side.

Billardiera fusiformis, *Labill.*

Hypocotyl as in B. longiflora, stained red, 8–15 mm. long.

Cotyledons long, linear, acute, tapering to the base but scarcely petiolate, dark green, glabrous, one-veined.

Stem with primary internodes undeveloped.

First leaves alternate, ovate-oblong, obtuse, lobed, coarsely and obtusely serrate, glabrous, green, pinnatinerved.

TREMANDREÆ.

Benth. et Hook. *Gen. Pl.* i. 133.

Fruit and Seed.—The ovary consists of two carpels, and is two-celled with one to three pendulous anatropous ovules in each cell attached close to the apex of the axile placentas. The raphe is ventral. There are three genera belonging to the order; one, Tetratheca, includes twenty species, the ovaries of which have from one to three ovules in each cell. When there are two they are superposed, but the third one is collateral. The fruit is a capsule dehiscing along the middle of each carpel, and the seeds have a shell-shaped twisted aril-like appendage at the chalaza. The testa is crustaceous, and in Tetratheca and Tremandra sparingly pilose. The seeds of Platytheca galioides are solitary in each cell and smooth.

The embryo is close to the hilum and embedded in a moderately hard endosperm, with the radicle superior; it is usually very small.

The Tremandreæ are slender, much branched shrubs, with alternate, opposite or whorled, narrow, and sometimes Heath-like leaves.

POLYGALEÆ.

Benth. et Hook. *Gen. Pl.* i. 134.

Fruit and Seed.—The pistil is superior, syncarpous, two-celled, consisting of two carpels. Exceptions to these general characters occur in Xanthophyllum with a one-celled ovary and parietal placentas, while there is only one carpel in Securidaca, several species of Monnina, and Krameria. In Trigoniastrum the ovary is three-celled, and in Moutabea often three- to five-celled. Typically the two cells each contain one ovule suspended from the top of the cavity; two collateral ovules occur in Krameria; and from two to six in Xanthophyllum. The pendulous and anatropous character is constant.

The fruit is capsular and loculicidally, rarely septicidally, dehiscent, or is dry or baccate and indehiscent. That of Securidaca and Trigoniastrum is a samara, that of Carpolobia and Mundtia a drupe. The fruit of Xanthophyllum, Moutabea, and Krameria is globose and indehiscent. That of Krameria, though primarily two-ovuled, is one-seeded and spiny or muricate. The seeds are pendulous, with a crustaceous testa, or velvety or pilose as in the case of Comesperma, and often furnished with an aril at the hilum as in Polygala. They also contain a large or small quantity of endosperm; but in a few abnormal genera such as Xanthophyllum, Moutabea, Krameria, and Securidaca, as well as in a few abnormal species of Polygala, there is no endosperm, and the cotyledons are large, thick and fleshy, so as to fill the seed. Intermediate stages are met with in other species of Polygala and other genera where the endosperm is reduced to a thin stratum surrounding the fleshy embryo. The embryo is always axile and straight, with a short superior radicle. The cotyledons in the species of Polygala observed are oblong or oval, auricled at the base; the embryo nearly equals the endosperm in length and width but not in thickness, as the seed-leaves are flat or nearly so. In exalbuminous seeds the cotyledons become plano-convex and very thick, so as to fill the seed; they are then more markedly auricled at the base in order to occupy the seed and yet leave space for the radicle. An instance may be seen in a section of the fruit and seed of Krameria. Besides Comesperma above mentioned the following have more or less hairy or pilose seeds, namely, Bredemeyera, Trigoniastrum, and Carpolobia.

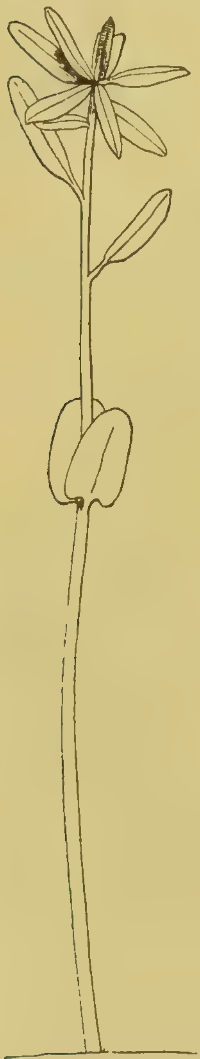
FIG. 195.—*Polygala rarifolia.* Nat. size.

As regards the means of dispersion, the fruits of Securidaca and Trigoniastrum, which are tall, generally climbing shrubs, are samaras; while those of Mundtia are fleshy, edible drupes; and those of Krameria bear a number of hooked hairs.

Cotyledons.—The yellowish-green colour of the seed-leaves of Polygala rarifolia would seem to indicate that they are gradually becoming functionless after germination and tending to be subterranean, and to act merely as a storehouse for reserve-material. It is more than probable, although the fact has not come under my notice, that in many of the species with exalbuminous seeds the cotyledons are subterranean after germination.

Polygala rarifolia, *DC.* (fig. 195).

Hypocotyl suffruticose, erect, terete, pubescent, pale green, 5·5 cm. above the soil.

Cotyledons broadly oblong, obtuse, shortly petiolate, cordate at the base, glabrous, pale yellowish-green, subcoriaceous; lamina 1·15 cm. long, one of them rarely slightly smaller, 7 mm. broad, petiole 2 mm. long.

Stem suffruticose, erect, terete, hairy, pale green; 1st internode 2·5 cm. long; 2nd 9 mm.; 3rd 8 mm.; 4th 1·25 mm.; the numerous succeeding ones crowded. Individuals, however, differ in the relative lengths of the internodes.

Leaves simple, entire, cauline, alternate, exstipulate, shortly petiolate, hairy on both surfaces, pale green; petioles terete, hairy, about 1–1·5 mm. long.

Nos. 1 and 2. Oblong, obtuse, minutely cuspidate.

Nos. 3 and 4. Linear-oblong.

Nos. 5–7. Oblong, the numerous succeeding ones linear-oblong, obtuse, minutely cuspidate.

FRANKENIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 140.

The ovary in this small Order consists of two to five carpels, but three is the most prevalent number. It is one-celled with as many parietal placentas as there are carpels, and the numerous small ovules are arranged in a double series. They are amphitropous or subanatropous, ascending on long slender funicles with an inferior micropyle. The fruit is a capsule dehiscing by as many valves as there are carpels. The small seeds are oblong or obovoid, with a crustaceous testa and a linear raphe.

The embryo is small, axile, and straight, the latter rather unusual in cases where the ovule is amphitropous. This is probably due to its small size, and the fact of its being embedded in the axis of the mealy endosperm. It is ovoid and cylindrical, and the radicle, which is close to the hilum, equals the cotyledons in length or is shorter.

There are from twelve to thirty species of Frankenia according to different authors, consisting of perennial evergreen herbs like our native F. lævis, or of much-branched suffruticose plants. No seedlings have come under my observation. The leaves of the older plant are small and opposite or fascicled on the shortened axillary shoots.

CARYOPHYLLEÆ.

Benth. et Hook. *Gen. Pl.* i. 141.

The ovary is superior, syncarpous, of two to five carpels, and usually one-celled, with the ovules arising from a central or basal placenta. There are two carpels in Dianthus, Velezia, Tunica, Gypsophila, Acanthophyllum, and Saponaria; three in Silene, Cucubalus, Stellaria, Spergularia, and others; and five in Lychnis, Cerastium, and others. But many of these vary greatly in different species; for instance, there are generally three in Arenaria, but species occur with two, four, or five carpels. In the young condition of the ovary septa are often discernible, but vanish as a rule during development of the fruit. There are, however, exceptions; and amongst those observed Silene gallica, S. noctiflora, S. tatarica, and S. depressa are three-celled even when mature. The ovules are usually numerous, but vary from two to many, Queria, however, having only one. They are amphitropous and ascending with the micropyle inferior or transverse. The fruit is a capsule dehiscing by teeth or valves, rarely fleshy as in Cucubalus and indehiscent as in the latter, and in Drypis.

The seeds are usually numerous, or few by arrest, smooth, tubercular, muricate, or reticulate, sometimes winged, as in Spergularia marina, and marginate, as in Tunica pachygona, some species of Spergula, Dianthus, &c.

As far as structure and form are concerned, there are two leading types in the Order with several modifications. The first is that of Velezia, Dianthus, and Tunica, which have peltate, dorsally compressed or much flattened seeds, with the hilum on the ventral face, and a straight embryo. By far the larger number, however, have reniform, obovoid, or globose seeds, frequently compressed laterally, and attached to the placenta by the edge, which is really the ventral surface. In the latter type the embryo is curved and peripheral, while the cotyledons are incumbent, rarely accumbent. The endosperm is mealy and lies in the bend of the embryo, on its sides, or even surrounds the whole embryo in peltate seeds such as those of Dianthus and Tunica. Endosperm is wanting in some species of Velezia and Dianthus. The whole Order as far as concerns the shape of the seeds and embryo may be considered as consisting of the two leading types above given with their modifications. The first is well exemplified in Dianthus plumarius (fig. 196). The seeds are broadly oblong-orbicular, imbricating in one row or series, forming a complete covering to the central columnar placenta, peltate, much compressed dorsally, slightly concave on the ventral face, and elevated on the dorsal aspect, forming a convexity agreeing in outline with the contained embryo, and traversed by a shallow ridge along the whole of the ventral aspect; the hilum is situated a little above the middle; and the testa, which is smooth and black, is prolonged into a short point at the micropyle, but not winged anywhere.[1]

The embryo is straight or slightly curved towards the axis, and transverse to it and enveloped on all sides by a thin layer of endosperm; the cotyledons are oblong, obtuse and comparatively broad; the terete radicle is about half the length of the cotyledons, and points into the little projection at the micropyle. D. Caryophyllus, D. chinensis, and D. prolifer, Tunica Saxifraga, and T. pachygona agree in all the main particulars with D. plumarius, but the testa of D. prolifera is muricate or echinulate, and that of Tunica Saxifraga minutely striate-reticulate.

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[1] Le Maout and Decaisne, Eng. Trans p. 256.

The most marked modification of the above type met with occurs in Tunica pachygona, the seeds of which are oblong or suborbicular, slightly angled at the margins, and distinctly winged all round except at the micropyle, where there is a narrow and moderately deep sinus, into which a little point projects, containing the tip of the radicle. The wing results from the absence of endosperm, whereby the testa on the dorsal and ventral aspect of the seed is allowed to come together. Velezia also offers a rather marked modification inasmuch as the seeds are deeply grooved or umbilicate on the middle of the inner or ventral face, while they are ovate or oblong in outline, semiglobular, thick, and convex on the outer face; the embryo is, however, straight, and the endosperm copious. The reniform and laterally compressed type of seeds may be seen by reference to Cerastium arvense (fig. 199) and D. plumarius (fig. 196), showing vertical and horizontal sections, as well as their attachment to the central column. The flattened seeds of Dianthus and Tunica are subservient to the purpose of distribution by the wind, and allow of the arrangement of a large number in a capsule, by overlapping like slates on a roof. Relatively to the size of the capsule, however, a still greater number can be packed away where the seeds are reniform and laterally compressed. This may be observed in Saponaria officinalis, where the lateral flattening is due to mutual pressure, and a large number of ovules and seeds are packed away in a little space. The number is increased in cases where the capsule is inflated as in Lychnis and Silene. In L. vespertina the seeds are horizontal or displaced in various ways, and arranged in a double series one over the other, by the funicles of the two sets being of different lengths. A single ovary will contain from 250 to 400, of which 240 to 370 or more reach maturity. They are ridged in the direction of the longer axis by the time they get ripe. Dianthus plumarius has 70 to 90 ovules, D. chinensis 70 to 80, and D. prolifer 35 to 45. D. prolifer, it may be remarked, is an annual species with small capsules.

Most or all of the species of the tribes Alsineæ and Polycarpeæ have small capsules with a moderate number of, sometimes with few, seeds. The capsule is one-seeded by arrest in

Brachystemma and Sphærocoma, and in some species of Acanthophyllum and Stellaria, while Queria as above mentioned is one-ovuled and one-seeded.

The form of the embryo in reniform seeds is well shown in the vertical section parallel with the embryo of Cerastium arvense (fig. 199). The seeds are small, reniform, laterally compressed, with very unequal ends, the larger one containing the cotyledons, and the smaller one the radicle of the embryo. The testa is densely covered with small protuberances—an extremely common occurrence amongst the reniform seeds of this Order. The embryo is curved and peripheral, but surrounded on the back with a thin layer of endosperm, although it is usual in other seeds of this type for the embryo to lie in immediate contact with the testa. A globular mass of floury endosperm lies in the sinus of the embryo on the ventral aspect of the seed. The cotyledons are linear, semiterete, obtuse, incumbent, and lying in the narrow plane of the seeds; the terete radicle tapers gradually to a blunt point, and is somewhat shorter than the cotyledons. A small indentation at the hilum seems the only thing hindering the embryo from making a complete circuit of the seed.

With the above type the following agree in all main particulars, namely, Gypsophila repens, G. Rokejeka, Saponaria officinalis, S. orientalis, S. Vaccaria, Silene gallica, S. Villarsii, S. noctiflora, S. tatarica, S. depressa, Cucubalus bacciferus, Lychnis diurna, L. vespertina, the species of Stellaria, Arenaria graminifolia, and others. A slight variation is met with in Lychnis Githago, where the thicker end of the seed contains the radicle and the thinner one the cotyledons; the reverse is usually the case when the seed is not of the same thickness throughout. A striking modification occurs in the species of Holosteum which have their ovules very much curved and folded so that one half lies against the other. The morphologically apical end containing the radicle is very narrow and forms a keel adnate to the face of the other half, which is much compressed. The cotyledons are incumbent and brought so close to the radicle that they nearly or quite touch it. There is little or no endosperm between them, but a considerable thickness of it on each side of the cotyledons so that the latter although semiterete have plenty of room to develop laterally and become broad.

A very important deviation not only from the type represented by Cerastium arvense, but also from the Order generally, occurs in Arenaria procumbens. The embryo is curved as usual in the shape of a horse-shoe, but the cotyledons are accumbent. The seed is reniform, very much compressed laterally, with a distinct notch at the base, and a double coat, finely reticulated on the surface. The cotyledons lie round the periphery of the seed just within the endosperm, and in the broader plane of the seed, yet they are semiterete and very narrow. Perhaps the exceeding thinness of the seed, which in transverse section is oblong with slightly indented sides and ends, may account for this particular manner of folding, although the narrowness of the cotyledons would hardly justify the conclusion. Buffonia Oliveriana (fig. 202), B. brachyphylla, and B. macrosperma agree with the above in having accumbent cotyledons, but they differ slightly in the form of the seeds, which are always few, generally two, in a capsule. They are very deeply horseshoe-shaped, and vertically, almost oblong or obovate. This unusual length is well marked in B. Oliveriana and B. macrosperma; and the latter has comparatively thick seeds. The cotyledons are always narrow and semiterete, or almost square in section in B. Oliveriana, and equal the radicle in length. The embryo as a whole is very much curved, almost encircling the whole of the greatest circumference of the seed.

A second most important variation occurs in some species with distinctly winged seeds, standing in the same relation to the reniform seeds with a curved embryo as Tunica pachygona does to Dianthus with flat seeds and a straight embryo. This type, which is very rare in the Order, is represented by Spergularia marina. The seeds are suborbicular, very much laterally flattened, and girt at the circumference by a moderately wide wing which is slightly notched at the hilum. In most cases winged seeds are adapted for dispersal by the wind, but in the case of Spergularia it perhaps serves the same object by enabling the seeds to float. The embryo is curved as usual, peripheral, and similar in all respects to others with incumbent cotyledons. S. marginata [1] agrees very closely with S. marina; but S. rubra, another British species, has wingless seeds. In Spergula also some species have winged seeds and others not. Drypis spinosa [2] stands in the same relation to the Caryophylleæ as Bunias orientalis does to the Cruciferæ. The embryo is spirally or circinately coiled, the cotyledons especially, and takes up the greater part of the seed. The radicle is simply hooked, with its tip brought round in contact with the cotyledons, while the small quantity of endosperm present lies in the sinus of the radicle. The seeds are somewhat compressed laterally.

Cotyledons.—There is considerable variation in the shape of the cotyledons after germination; but those observed may be roughly classed under six leading types or forms. All are entire, and they vary chiefly in size and outline. Some of them are moderately fleshy in character, while the greater number are so opaque that no venation is discernible, or at most a midrib only. Saponaria Vaccaria is exceptional, and it seems that the cotyledons of no two species of this genus are exactly alike.

Taking Dianthus Caryophyllus (fig. 197) as the first type, it is characterised by broadly oblong cotyledons, rounded at the apex, tapering into the petiole, glabrous, fleshy, pale green, opaque. D. prolifer and D. ciliatus agree in all the main points, but the cotyledons of the former are proportionately shorter, retuse, inclining to ovate, and minutely scabrid at the margin. Their form in all cases bears an evident relation to the shape of the peltate, flattened seed and embryo. The petioles, it may be noted, are short and connate at the base, forming a cup round the plumule, and this character is the prevailing one throughout the Order.

The next type is represented by Tunica prolifera (fig. 198), which has broad, suborbicular, petiolate, thin but opaque cotyledons, with obscure venation. They doubtless derive their shape from that of the seed, which is generally orbicular or discoid, or occasionally inclined to oblong as in T. pachygona. Saponaria orientalis may be placed here, as it has broadly ovate or suborbicular cotyledons when full grown; they also show an alternate, penninerved venation. While yet in the seed they are linear, longer than the radicle, incumbent, and otherwise resemble those usually found in the reniform or suborbicular and laterally flattened type of seeds, but after germination they become successively oblong-elliptic, elliptic, and ultimately suborbicular, so that their form is due to growth subsequent to germination, and does not depend upon that which obtains while yet in the seed.

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[1] Le Maout and Decaisne, p. 258.

[2] *Ibid.* p. 255.

A third type is shown by Saponaria Vaccaria. The cotyledons are narrowly oblong, obtuse, shortly petiolate and penninerved, and closely resemble the primary leaves in that respect as well as in form. The seed is large (3–4 mm. in width), suborbicular, and slightly flattened laterally. The embryo is also large and curved round the periphery, and the cotyledons in germination keep much the same shape but attain a large size on account of the large store of reserve material in the seed. They are also unequal in size in the proportion of 25 to 29 mm.; and this peculiarity no doubt takes its origin in the seed, where the outer cotyledon would be the longest. They are long and narrow during germination, but increase in width afterwards. Lychnis Githago has long and broadly spathulate, sessile cotyledons connate at the base. They are opaque and show a midrib only.

A large number of species have broad cotyledons of moderate length somewhat similar to those of Dianthus, but they are pointed and more or less evidently narrowed at both ends. Those that may be grouped under this head vary somewhat between ovate-lanceolate, ovate, and elliptic or oblanceolate; but all agree in being pointed. Cerastium arvense (fig. 200), Silene echinata, and Silene rubella may be given as representatives of the three subtypes respectively. The cotyledons of C. arvense are ovate-lanceolate, petiolate, obtusely pointed, slightly mucronate, tapered to the base, distinctly one-nerved, and connate at the very base. Those of Silene echinata are broadly ovate, short, moderate in size, shortly petiolate, and faintly trinerved. Those of S. rubella are oblanceolate, tapered to a rather broad, connate base, and unequal in size in the ratio of 9·5 to 11 mm. Silene

Schweinfurthii agrees pretty closely with the latter, and Saponaria calabrica merely differs in being somewhat more elliptic.

The fifth type is represented by Sagina procumbens (fig. 201), which has small, subulate, acute cotyledons, broadest at the base, and connate there, forming a cup round the plumule, 1·5–2 mm. long, and 1 mm. broad at the base. A sixth very distinct type is met with in Spergula arvensis, the cotyledons of which are linear, semiterete, acute, fleshy, glabrous, green, without discernible venation, about 22·5 mm. long, and in all respects very similar to the primary leaves.

The Order Caryophylleæ consists of 800 to 1200 species according to different authors. They are chiefly confined to the northern hemisphere, and are found in greatest numbers in extratropical regions, extending into the arctic and alpine; they are rarer in the southern hemisphere and very rare in the tropics, where they occur only on mountains.

Dianthus plumarius, *L.* (fig. 196).

Fruit an oblong-cylindrical capsule, one-celled, many-seeded, dehiscing at the apex by four short valves or teeth.

Seeds broadly oblong-orbicular, imbricated on a central column, peltate, much compressed dorso-ventrally, slightly concave on the ventral aspect, and raised on the dorsal into a convexity agreeing in outline with the contained embryo, traversed throughout its longest axis on the ventral aspect by a ridge; testa black; hilum ventral a little above the middle of the seed, with a projection at

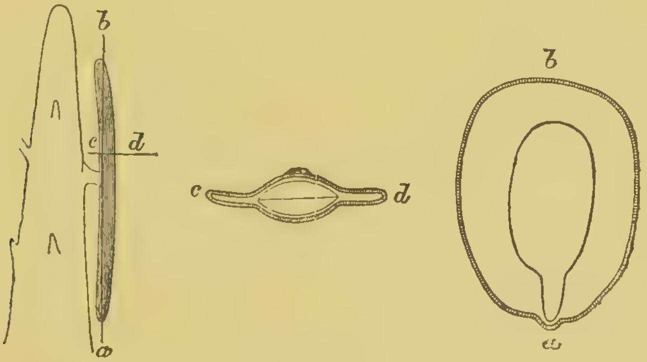

FIG. 196.—*Dianthus plumarius*, × 15.

either end, one of which towards the end farthest from the micropyle is the raphe; micropyle produced into a little point.

Endosperm copious, white, farinaceous.

Embryo comparatively large, slightly curved towards the axis; cotyledons oblong, obtuse, entire, broad; radicle cylindrical, obtuse, pointing into a little projection at the micropyle.

Diànthus Caryophyllus, *L.* (fig. 197).

Hypocotyl very short, tapering into the root.

Cotyledons broadly oblong, obtuse, tapering into the petiole, glabrous, fleshy, pale green; lamina 1·3 cm. long, 9·5 mm. broad; petiole flattened, shallowly grooved above, perfoliate, 6 mm. long.

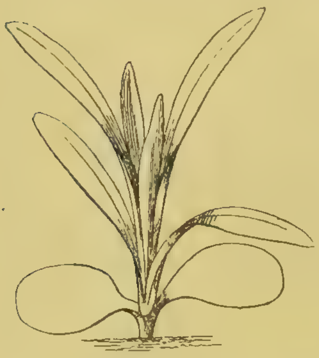

FIG. 197.—*Dianthus Caryophyllus.* Nat. size.

Stem herbaceous or shrubby below, erect, ultimately decumbent, glabrous, terete; internodes crowded in the seedling stage; nodes thickened.

Leaves simple, entire, radical and cauline, opposite, decussate, perfoliate, glabrous, glaucous, exstipulate, sessile.

1st pair linear, spathulate, obtuse, channelled on the lower half, arching, subcarinate, especially on the lower half.

2nd pair linear, obtuse, broadest above the middle.

Dianthus prolifer, *L.*

Primary root long, tapering, with numerous short lateral rootlets.

Hypocotyl tapering insensibly into the root, short, glabrous.

Cotyledons broadly ovate, retuse, shortly petiolate, glabrous, minutely scabrous at the margin, light green, with an inconspicuous midrib and a few slender, incurved, lateral veins; lamina 6 mm. long, 4·5 mm. wide; petiole flattened, dilated at the base and perfoliate, 2 mm. long.

Leaves subperfoliate at the base, spiny-ciliate at the margin and on the strong subcarinate midrib beneath, otherwise glabrous, deep green, shining, with a prominent midrib and a few lateral ascending nerves that unite with those next above them, but very indistinct in the first two pairs of leaves.

1st pair spathulate, obtuse.

2nd pair oblanceolate or narrowly spathulate, subacute.

3rd pair linear, obtuse.

Tunica pachygona, *Fisch. et Mey.*

Capsule oblong-ellipsoid, glabrous, enclosed in the shortly five-toothed, fifteen-ribbed, persistent calyx, which is nearly or quite as long, one-celled, with a central placenta, and many seeds, dehiscing at the apex by four valves.

Seed oblong-orbicular, thin and much flattened dorsally, entire or slightly angled at the margins, winged all round except at the tip of the radicle where a narrow shallow sinus is formed, glabrous, black. Except for an elevation conforming in outline to that of the embryo the seeds are nearly flat and attached to the placenta a little above the middle and much overlapping one another; hilum forming a little round spot above the middle of the seed on the ventral aspect; micropyle at the lower end of the seed, lying in the sinus; raphe and chalaza inconspicuous.

Endosperm forming a thin layer throughout the seed, except in the wing, but much thinner around the embryo, white, fleshy, or subfarinose.

Embryo straight, central, much narrower than the endosperm and a little shorter, colourless; cotyledons oblong-ovate, obtuse, entire, plano-convex or nearly flat, lying in the broad plane of the seed with their backs to the axis; radicle terete, obtuse, about half as long as the embryo, embedded in a thin layer of endosperm close to the micropyle.

Tunica prolifera, *Scop.* (fig. 198).

Primary root slender, tapering, flexuose, with a few short lateral rootlets.

Hypocotyl suberect, herbaceous, about 2 cm. long, ·5–1 mm. thick, round, slightly pubescent under the seed-leaves.

Cotyledons nearly equal, stalked, including petiole about 1 cm. long, 7 mm. broad, suborbicular or somewhat spathulate, rounded, entire, with very obscure nervation, glabrous, not very thick nor persistent, dull green above, paler below.

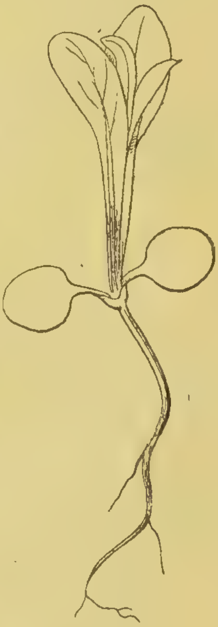

FIG. 198.
Tunica prolifera.
Nat. size.

Stem very short, elongated when about to flower.

Leaves simple, entire, radical and cauline, opposite, exstipulate, petiolate in the early stages or very much narrowed at the base, ultimately narrow, sessile, with a distinct midrib and a few scattered lateral nerves, glabrous, deep green above, paler beneath.

1st and 2nd pairs spathulate, much narrowed to a petiole-like base.

Saponaria Vaccaria, *L.*

Hypocotyl erect, terete, glabrous, 3–4 mm. long, light green or colourless.

Cotyledons somewhat fleshy, unequal, linear-oblong, obtuse, entire, shortly petiolate, glabrous, green, pinnatinerved like the leaves.

Stem erect, nearly square, herbaceous, glabrous; 1st internode 5–7 mm. long, 2nd very short.

First leaves simple, entire, cauline, opposite, decussate, linear-oblong, obtuse, sessile, tapering slightly to the base, where they are ciliate, glabrous, green, fleshy, indistinctly pinnatinerved.

Saponaria calabrica, *Guss.*

Primary root slender, tapering downwards, with numerous lateral rootlets.

Hypocotyl as in S. Vaccaria but 5–6 mm. long.

Cotyledons oblong, one-veined; petiole short, broad, scarcely channelled.

Stem with primary internodes undeveloped.

First leaves radical, petiolate, rotundly oblong or almost spathulate; 2nd pair of leaves slightly hairy, one-veined like the cotyledons; petioles broad, flat, sheathing at the base, shallowly channelled on the upper surface.

Saponaria orientalis, *L.*

Hypocotyl as in preceding species, erect, terete, glabrous.

Cotyledons ovate-oblong, indistinctly one-veined like the leaves.

Stem herbaceous, erect, square; primary internodes but slightly developed.

First leaves cauline, ovately-oval or oblong, obtuse, otherwise as in preceding species; petioles rather long, glabrous, deeply furrowed on the upper side.

Silene echinata, *Otth.*

Primary root tapering downwards, with short lateral rootlets.

Hypocotyl erect, very short, or tapering indistinguishably into the root, pale green or colourless.

Cotyledons ovate, obtuse, entire, petiolate, trinerved from the base, the lateral ones submarginal, undulate or wavy, curved inwards and uniting with the midrib close to the apex, alternately nerved upwards and obscurely reticulate, glabrous, light green; lamina 6–8 mm. long, 4–5 mm. wide; petiole grooved above, connate at the base, 1·5–2 mm. long.

Stem herbaceous, annual, erect, and developed when about to flower; primary internodes undeveloped.

Leaves simple, entire, radical and cauline, opposite, exstipulate, petiolate, obscurely, alternately incurvinerved, hairy on both surfaces, light green above, paler beneath; petioles channelled above, dilated and clasping at the base and slightly connate, coarsely hairy at the margins or edges of the channel.

1st pair short, obovate, very obtuse and rounded at the end.

2nd pair similar, but much larger.

3rd and 4th pairs spathulate, obovate, narrower and inclined to be oblong.

Silene rubella, *L.*

Primary root tapering downwards, with numerous long lateral rootlets.

Hypocotyl short, obconical, green or almost colourless.

Cotyledons rather fleshy, linear-oblong or lanceolate, indistinctly one-nerved like the leaves, unequal.

Stem, 1st internode 1–1·5 mm. long; 2nd 6–7 mm.; 3rd very short.

First leaves entire, often wavy, cauline, spathulate or cuneate, tapering to the base, but scarcely petiolate, obtuse, glabrous, one-nerved.

Lychnis Githago, *Lam.*

Hypocotyl short, hardly appearing above the soil.

Cotyledons broadly oblong, obtuse, entire, somewhat fleshy, petiolate, connate at the base, glabrous, dark green, indistinctly one-nerved.

Stem with primary internodes undeveloped.

First leaves simple, entire, radical, opposite, oblong-lanceolate, subacute, exstipulate, pubescent, with the hairs very fine and silky, tapering to the base, sessile, light green, indistinctly pinnatinerved.

Cerastium arvense, *L.* (fig. 199).

Fruit a capsule, cylindrical or slightly curved and narrowed upwards, one-celled, many-seeded, dehiscing at the apex by ten teeth.

Seed reniform, with very unequal ends, appearing laterally compressed simply because curved, small, densely covered with small protuberances, brown; the smaller end containing the radicle, the larger one the cotyledons; hilum on the large end of the seed close to the edge of the basal notch; raphe none.

Endosperm in the mature seed forming a round mass between the embryo and the basal notch, also an extremely thin layer round the periphery of the seed, and surrounding the embryo, floury, white.

Embryo long and narrow, curved round the periphery of the seed, pale yellow; cotyledons linear, obtuse, entire, semiterete, lying in the narrow way of the seed with their backs to the hilum; radicle cylindrical, slightly narrowed to an obtuse tip, somewhat shorter than the cotyledons and incumbent.

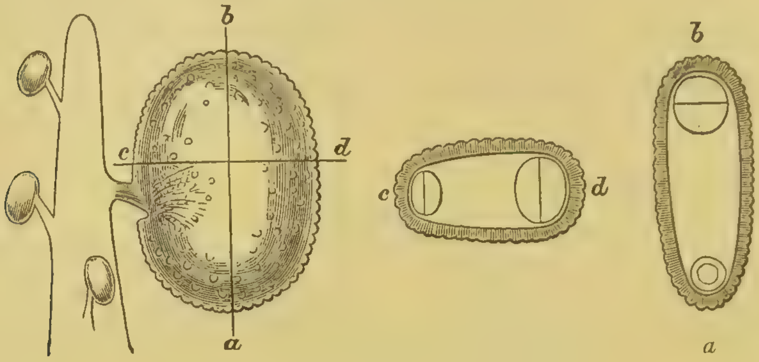

Fig. 199.—*Cerastium arvense*, × 15.

The form and arrangement of the seeds in Caryophylleæ has been already referred to (see *ante*, p. 25).

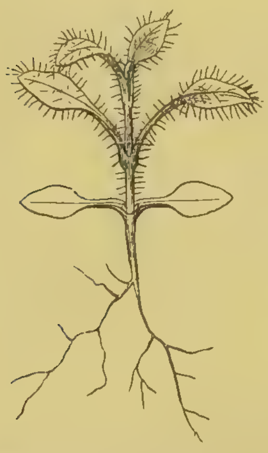

Fig. 200.—*Cerastium arvense*. Half nat. size.

Seedling (fig. 200).

Hypocotyl erect or slightly decumbent, thickened upwards, glabrous, pale green, about 4–5 mm. long.

Cotyledons ovate-lanceolate, obtuse, petiolate, glabrous, slightly mucronate, distinctly one-nerved, tapered at the base into the petiole; lamina about 7 mm. long, and 3 mm. wide; petiole channelled above, convex beneath, perfoliate at the base, about 3 mm. long.

Stem herbaceous, primarily erect, ultimately decumbent, terete, pale green, glabrous, somewhat thickened at the nodes; 1st internode 4·25 mm., 2nd 6·5 mm. long.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, slightly hairy above and occasionally on the midrib beneath (at least in seedlings), indistinctly trinerved; midrib with a few short, alternate, ascending nerves uniting with the longitudinal, lateral, slender, wavy submarginal ones; petioles channelled above, subcarinate beneath, slightly hairy, connate at the base.

1st to 3rd pairs spathulate, or often broadly spathulate, obtuse, mucronate.

Arenaria procumbens, *Vahl.*

Fruit a capsule, small, ovoid, one-celled, several-seeded, dehiscing by the same number of valves as there are carpels.

Seed reniform, much compressed laterally, with a distinct notch at the base, very finely reticulated, pale brown; seed-coat double; the testa membranous, pale brown; the tegmen thinner, whitish; hilum and micropyle contiguous, basal in the notch.

Endosperm copious, farinaceous, white.

Embryo curved round just within the periphery of the endosperm, colourless; cotyledons accumbent, sometimes somewhat obliquely linear, obtuse, entire, plano-convex, lying in the broad plane of the seed with their edges to the axis (presumably on account of the seed being thin and much compressed laterally); radicle terete, obtuse, about equal in length to the cotyledons, and curved in conformity with the curvature of the seed.

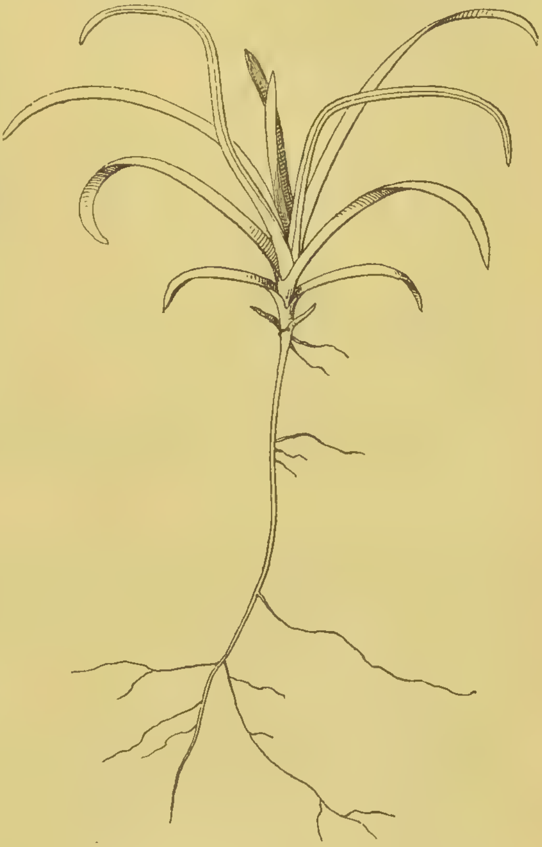

FIG. 201.—*Sagina procumbens*, × 3.

Sagina procumbens, *L.* (fig. 201).

Primary root tapering downwards, with numerous slender, lateral rootlets and abundantly provided with root-hairs.

Hypocotyl very short or completely suppressed.

Cotyledons small, subulate, acute, much broader at the base, where they are connate and form a little cup round the stem, about 1·5–2 mm. long, and 1 mm. broad at the base.

Stem herbaceous, with the lower very slightly developed internodes covered by the connate and sheathing bases of the leaves; primary one remaining short and barren; lateral shoots or branches elongating and fruiting.

Leaves simple, entire, radical and cauline, opposite, exstipulate, sessile, dilated, connate and sheathing at the base, glabrous, and covered with numerous, elevated, very minute, hyaline points, bright green, without discernible venation, or with the midrib indicated by a slightly elevated ridge on the under side.

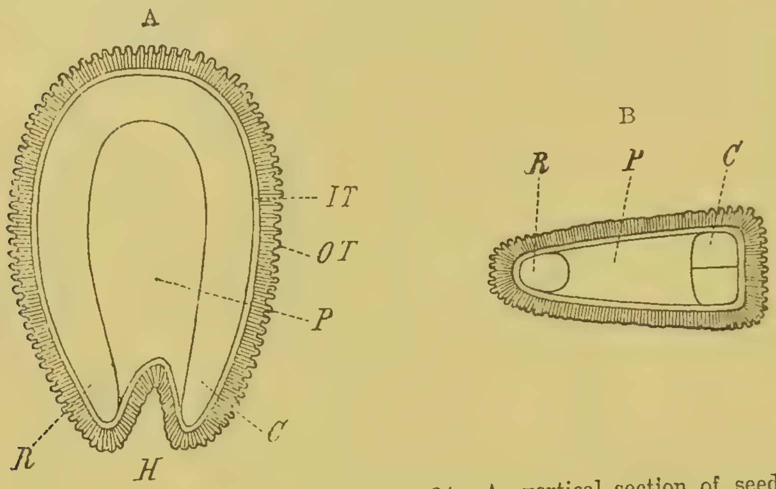

FIG. 202.—*Buffonia Oliveriana*, × 24. A, vertical section of seed: *R*, radicle; *H*, hilum; *C*, cotyledon; *P*, endosperm; *O T*, testa; *I T*, tegmen. B, transverse section of seed: *R*, radicle, *P*, endosperm; *C*, cotyledon.

1st pair narrowly linear, acute, flattened above.

3rd to 5th pairs narrowly linear, but still much broader than the first pair, acute, or tipped with a slender hyaline seta or bristle, convex above and minutely revolute at the margins.

Buffonia Oliveriana, *Ser.* (fig. 202).

Fruit a capsule, obovoid, much compressed laterally, pale-coloured, glabrous, one-celled, generally two-seeded, dehiscing longitudinally by two valves.

Seed vertical, oblong, much compressed laterally, obtuse at the upper end, notched at the base, owing to the curvature of the ovule, finely and closely rugoso-reticulate and even developed into numerous small points or teeth round the margin; hilum and micropyle contiguous, basal; raphe none.

Endosperm central, copious, farinaceous, white.

Embryo much curved round the periphery of the endosperm, yellowish-white; cotyledons linear, plano-convex, or semiterete, obtuse, lying in the broader plane of the seed, accumbent with their edges to the hilum and placenta, the two together thicker than they are wide; radicle terete, obtuse, as thick at the base as the cotyledons are broad, but thicker above the middle, and as long.

I figure this species because the cotyledons, like those of B. brachyphylla and Arenaria procumbens, are accumbent.

Buffonia brachyphylla, *B.H.* (fig. 203).

Capsule small, ovoid, one-celled, generally two-seeded, but often one-seeded, dehiscing to the base by two valves.

Seed reniform, much compressed laterally, and comparatively thin, with a basal notch, minutely and finely reticulated, brown; testa comparatively thick; tegmen thin, membranous.

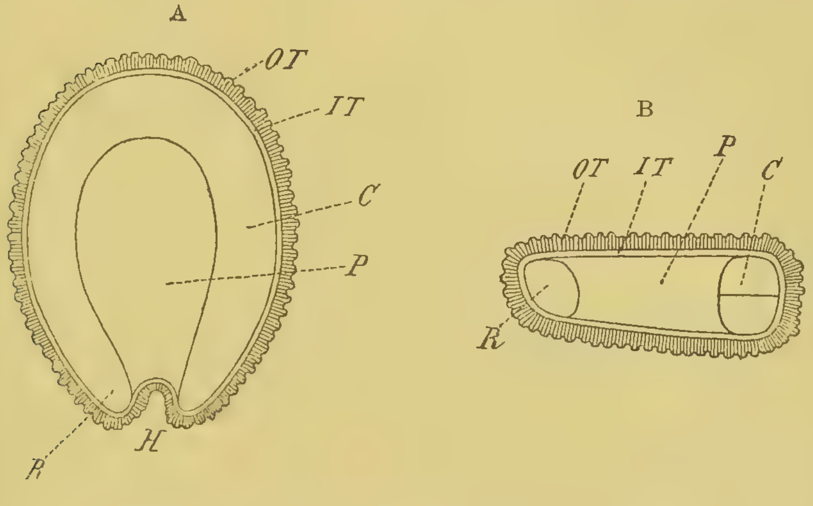

FIG. 203.—*Buffonia brachyphylla*, × 20. A, vertical section of seed: *R*, radicle; *H*, hilum; *P*, endosperm; *C*, cotyledon; *I T*, tegmen; *O T*, testa. B, transverse section of seed: *O T*, testa; *I T*, tegmen; *P*, endosperm; *C*, cotyledon; *R*, radicle.

Endosperm mealy or farinaceous.

Embryo as in the preceding species.

Spergula arvensis, *L.*

Hypocotyl erect, terete, glabrous, 5–8 mm. long, light green.

Cotyledons linear, semiterete, acute, entire, fleshy, glabrous, green, no venation apparent.

Stem with primary internodes undeveloped.

First leaves simple, entire, radical, opposite, decussate, linear, cylindrical, acute, sessile, fleshy, glabrous, green, without any apparent venation; subsequent leaves in pseudo-whorls of from six to eight.

PORTULACEÆ.

Benth. et Hook. *Gen. Pl.* i. 155.

Fruit and Seed.—The pistil is syncarpous and free, or half inferior in Portulaca, one-celled, two- to many-ovuled, and consists of three, rarely two, carpels. The amphitropous ovules vary from two to many, except in Portulacaria, which has only one, and arise from the base of the ovary separately, or the funicles are connate into a central column.

The fruit is a capsule, splitting by as many valves as there are carpels, or dehiscing circumscissly as in Portulaca; rarely indehiscent as in the one-seeded winged fruits of Portulacaria and Silvæa. The seeds are numerous or solitary by arrest, and reniform, or lenticular, laterally compressed, or obovoid; testa generally crustaceous, shining and smooth or often granulate as in species of Portulaca, sometimes furnished with an arilloid, or swelling of the funicle, as in Talinum. The embryo is nearly always curved round the periphery of a scanty, farinaceous endosperm, when the cotyledons about equal the terete radicle in length.

A good type of the Order is furnished by Portulaca grandiflora, the seeds of which are reniform, laterally compressed, with a thick and a thin end, and a minutely granulate crustaceous and shining testa.

As regards means of dispersion, Portulacaria has winged fruits, and Grahamia winged seeds; in Anacampseros some species have seeds with three wings while others are wingless.

The embryo is curved round the periphery of the seed, enclosing in its sinus a small quantity of endosperm, and nearly encircling the greatest circumference; the cotyledons are plano-convex, linear-oblong, and being situated in the wider end of the seed, are much wider than the terete radicle, which they equal in length. They are also incumbent and lie transversely to the wider plane of the seed.

Calandrinia umbellata, C. pilosiuscula, and Spraguea umbellata agree very closely with Portulaca except that the seeds of Spraguea are thickest in the middle and taper to each end, so that the cotyledons are narrower for the size of the seed than in the type given. A more remarkable exception occurs in Claytonia perfoliata (fig. 204), the embryo of which lies in the broader plane of the seed. The cotyledons are nevertheless very narrow, linear, plano-convex, and accumbent, perhaps for the reason suggested on page 69. The embryo seems to originate with its cotyledons in the narrow plane of the seed while yet straight; but certainly as soon as it begins to curve in conformity with the outline of the seed, the cotyledons lie in the broad plane with their edges to the axis. When first observable with a simple lens, the embryo is a small, nodular, obcordate body, but it soon becomes oblong, and the cotyledons attain such a thickness as to become closely adpressed to one another; in the next stage it is cylindrical, and soon after commences to curve and ultimately attains a horse-shoe shape.

Exceptions to the general rule occur in Grahamia, Talinopsis, and sometimes in Anacampseros, where the embryo is almost straight, and the seeds have only a scanty endosperm. The seeds of Grahamia are also irregularly obovate, subreniform, very much compressed laterally, and girt with a membranous wing; in Talinopsis they are obovate-oblong, incurved and hooked but wingless; while in some species of Anacampseros they are angled or compressed and three-winged, but in others wingless.

Cotyledons.—As far as observed there are two distinct types of cotyledons, namely, a broad and a narrow one. One of the broadest types occurs in Portulaca grandiflora, notwithstanding the extreme minuteness of the seeds. The cotyledons however lie in the narrow plane of the seed, but in its widest part, and they are consequently several times as wide as the radicle is thick. When fully developed after germination they are oblong-oval, obtuse, fleshy, shortly petiolate, about 17 mm. long and 4 mm. broad. Calandrinia umbellata and Spraguea umbellata agree with the above in the relative width of the cotyledons, but the latter are only 2·25 mm. long and 1·25 mm. broad in Spraguea. They are oblong-ovate, obtuse, sessile, and subfleshy. There are a few notable points to be observed in the germination of the seeds. In some cases the testa splits along the side of the cotyledons, which, meeting with little resistance, emerge here, contrary to the usual rule in seeds that the radicle is first protruded. They continue to grow till the endosperm becomes exhausted through the medium of the radicle, when the seedling, unable to make any further progress, dies, unless the conditions are favourable for the emission of adventitious roots, whereby it can lay hold of the soil and become established. When however the seeds have been properly covered with soil the radicle emerges first, the arching hypocotyl pulls the cotyledons out of the testa, and after it has become straight these unfold to the light. The testa is however frequently carried up on the cotyledons, when it exhibits a vertical cleft of considerable size, thus allowing the escape of the cotyledons, which are comparatively broad, oblong, obtuse, and sessile. In the mature seed the cotyledons are long, narrow, and quite typical of the Order ; but after germination or during it, they develop more in breadth than length, and remain comparatively short. Sown under glass they germinated in ten days.

Several species of Calandrinia, including C. pilosiuscula and C. speciosa, agree with Claytonia in the narrowness of their cotyledons, also some species of Talinum, and it is probable that several other genera of the same habit have similar cotyledons; in C. umbellata they are broader, and some other species of Calandrinia which differ in habit and have broad, fleshy, mostly radical leaves, may possibly have different cotyledons.

Portulaca grandiflora, *Hook.*

Hypocotyl erect, terete, reddish, glabrous, 10–15 mm.

Cotyledons oblong-oval, obtuse, fleshy, glabrous, stained with red underneath, shortly petiolate, about 17 mm. long including the petiole, 4 mm. broad.

Stem herbaceous, erect in the early stages, but afterwards procumbent, terete, glabrous with tufts of long white hairs springing from the axils of the cotyledons.

Leaves simple, entire, flat, cauline, alternate, exstipulate, very shortly petiolate, fleshy, glabrous, often tinged with red beneath; petioles very short, slightly channelled above.

Nos. 1 and 2. Ovate, obtuse, or faintly mucronate, with small tufts of white hairs or setæ in their axils.

Claytonia perfoliata, *Don* (fig. 204).

Fruit a capsule, globose or ovoid, membranous, dehiscing by three valves.

Seed orbicular-subreniform, much compressed laterally, small, with the auricles on each side of the hilum nearly or quite equal; testa glabrous, shining, black, crustaceous; hilum basal in the sinus, and apparently equidistant from apex of cotyledons and radicle; funicle partly or wholly persistent.

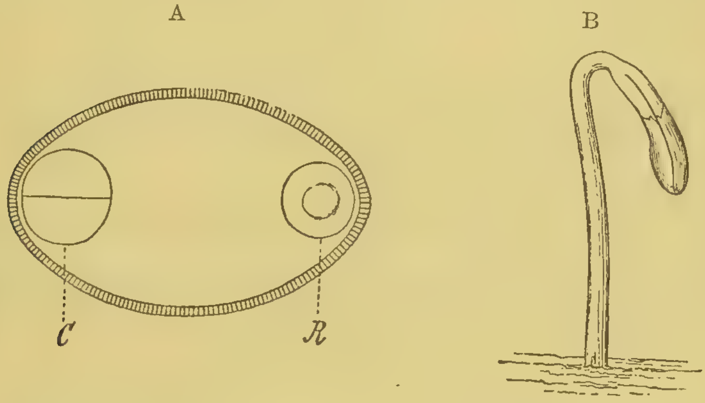

FIG. 204.—*Claytonia perfoliata.* A, transverse section of seed: *C*, cotyledons; *R*, radicle, × 15. B, seedling, showing the thickness of the two cotyledons combined, × 6.

Endosperm copious, farinaceous, white, forming a thin layer round the embryo, and a much larger mass inside.

Embryo much curved round the periphery of the seed, just within a thin layer of endosperm; cotyledons narrowly linear, obtuse, entire, colourless, accumbent; radicle cylindrical or terete, obtuse, curved round the periphery of the seed, about as long as the cotyledons.

Seedling (fig. 205).

Primary root normal, annual.

Hypocotyl terete, very short, reddish, glabrous, 2·5 mm. long.

Cotyledons linear, elongated, fleshy, flattened, glabrous, pale green, becoming reddish when old, broadest above the middle, narrowed towards the base, then suddenly dilated, amplexicaul or slightly perfoliate, 2·3 cm. long, greatest breadth 1·5 mm.

Stem herbaceous, annual, developed when about to flower; many primary nodes undeveloped.

Leaves simple, entire, radical and cauline, alternate, exstipulate, petiolate, glabrous, rather fleshy, bright green; petioles flattened above or shallowly grooved, long, slender, fleshy, glabrous, dilated and amplexicaul at the base.

Nos. 1 and 2. Narrowly spathulate with a long petiole.

No. 3. Much broader.

Nos. 4–8. Rhomboid, obtuse or subacute, on long petioles.

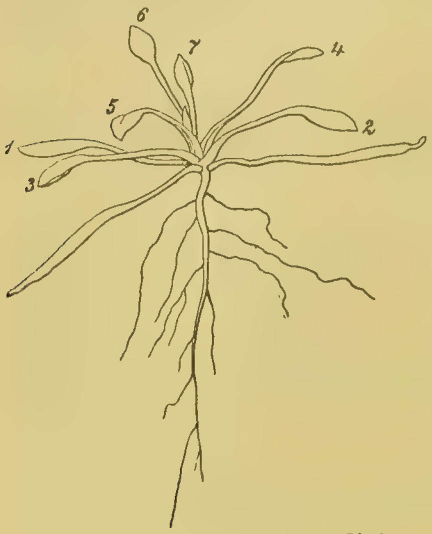

Fig. 205.—*Claytonia perfoliata.* Nat. size.

Spraguea umbellata, *Torr.* (fig. 206).

Fruit a globular capsule, compressed, several-seeded, dehiscing by two valves.

Seed reniform-orbicular, laterally compressed, thickest in the middle, and narrowed to the edge, especially towards the basal edge, glabrous, shining, minutely pitted all over; testa rather thick, hard and crustaceous; hilum basal, but lying in a sinus which is

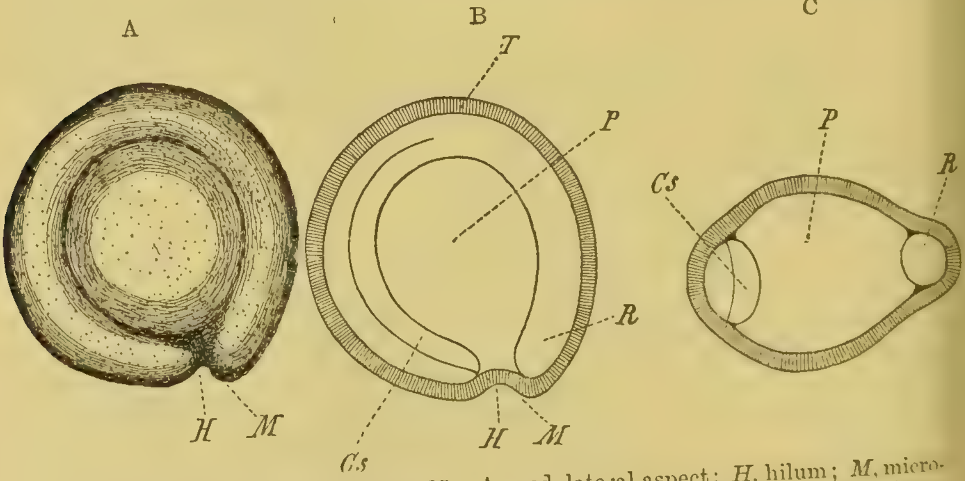

Fig. 206.—*Spraguea umbellata*, × 25. A, seed, lateral aspect: *H*, hilum; *M*, micropyle. B, vertical section of seed: *H*, hilum; *M*, micropyle; *Cs*, cotyledons; *R*, radicle; *P*, endosperm; *T*, testa. C, transverse section of seed: *Cs*, cotyledons; *P*, endosperm; *R*, radicle.

not quite central, the radicle lying in the smaller auricle of the sinus and the cotyledons in the larger one; micropyle on one side of the hilum, the chalaza on the other.

Endosperm copious, farinaceous, white, lying in the centre of the seed and extending to the broader circumference only at the base.

Embryo comparatively large, much curved, occupying the circumference of the seed, except a small piece at the base peripheral and entirely outside the endosperm (in the specimens examined), colourless, but darker than the endosperm; cotyledons linear, plano-convex, or semiterete, obtuse, entire, incumbent, lying in the narrow plane of the seed with their backs to the placenta, about as long and as broad as the radicle; radicle terete or cylindrical, obtuse, abutting with its tip against the micropyle.

Calandrinia pilosiuscula, *DC.*

Hypocotyl erect, terete, glabrous, colourless or faintly tinged with red, 8–10 mm. long.

Cotyledons 15–22 mm. long, linear, obtuse, tapering slightly at the base, entire, covered with a minute scarcely perceptible pubescence, green, without any apparent venation.

Stem with primary internodes undeveloped.

First leaves simple, entire, radical, alternate (first pair apparently opposite), exstipulate, linear, obtuse, slightly tapering to the base, covered with a very minute pubescence, one-nerved, green.

Calandrinia umbellata, *DC.*

Hypocotyl 4–6 mm. long, stained with red.

Cotyledons fleshy, oblong-oval, obtuse, entire, shortly petiolate, glabrous, dark green, without any apparent venation.

Stem as in C. pilosiuscula.

First leaves linear-lanceolate, tapering to the base but hardly petiolate, covered with rather long glandular hairs, otherwise as in C. pilosiuscula.

TAMARISCINEÆ.

Benth. et Hook. *Gen. Pl.* i. 159.

Fruit and Seed.—The one-celled ovary consists of from three to five carpels, and as many parietal placentas, which project into the interior and often become more or less united with one another, thus imperfectly dividing it into loculi. The placentas also vary greatly in length in the different species, some rising but a short way above the base of the ovary, while in other cases they nearly equal the length of the cavity. The ovules vary from two to many on each placenta and are erect and anatropous, with the raphe on the ventral aspect and an inferior micropyle. The fruit is a capsule dehiscing by valves and liberating the seeds, which are furnished with a curious contrivance for their distribution. In some cases they are prolonged into a slender beak covered with long silky hairs, while others have no beak but are covered all over with long hairs, and a third type is furnished with wings. The seeds contain a mealy or fleshy endosperm, sometimes in very small quantity, or there may be none at all as in Tamarix and Myricaria. The embryo is straight with flat cotyledons, and a short radicle close to the hilum; and where endosperm is wanting it entirely fills the seed, to which it conforms in shape.

The Tamariscineæ include some forty species distributed amongst five genera, and consist of very finely branched shrubs, rarely trees or rigid herbs. The leaves are alternate, minute, and often scale-like.

ELATINEÆ.

Benth. et Hook. *Gen. Pl.* i. 162.

Fruit and Seed.—The ovary contains from two to five cells, corresponding to the number of the sepals and petals in the different species. The ovules are numerous on the inner angle of the cells, horizontal or ascending, anatropous, with a lateral or nearly superior raphe. The fruit in dehiscing splits along the inner edge of the septa, leaving a central column bearing the seeds, or often along the outer edge, leaving the septa attached to the central column. The seeds are numerous, cylindrical, straight, or slightly curved as in Elatine triandra, or very much curved like the head of a shepherd's staff as in E. Hydropiper, strongly and closely striated transversely, and exalbuminous or with a thin layer only of endosperm. In some of the species of Bergia they are smooth, and these species are sometimes placed in a separate genus, Merimea.

The embryo is cylindrical, conforming in outline to that of the seed, which it wholly occupies. The radicle is close to the hilum, much longer than the cotyledons and equalling them in width.

The Elatineæ include twenty species of slender aquatic or marsh herbs or small shrubs, creeping or spreading diffusely. They are widely dispersed throughout the world, but most abundant in the Old World, growing in shallow water like our native Elatine Hydropiper, and E. hexandra.

HYPERICINEÆ.

Benth. et Hook. *Gen. Pl.* i. 163.

Fruit and Seed.—The carpels vary from three to five ; rarely reduced to one, as in Endodesmia calophylloides. The ovules are usually numerous, ascending or horizontal from parietal or axile placentas, and anatropous with a lateral or superior raphe. The fruit is a capsule in the tribes Hypericeæ and Cratoxyleæ, but baccate and indehiscent in the Vismieæ. That of Endodesmia, containing only one pendulous seed, is a drupe, while that of Haronga forms a drupe with five woody pyrenes as in Cratægus. The seeds are exalbuminous, straight or rarely curved, with a crustaceous, or more often membranous, testa expanded into a wing in Eliæa and Cratoxylon. The embryo is generally straight, but incurved in a few of the species of Hypericum, and always conforms to the seed. The cotyledons are flat, except in Endodesmia, where they are thick and fleshy ; they are longer than the radicle

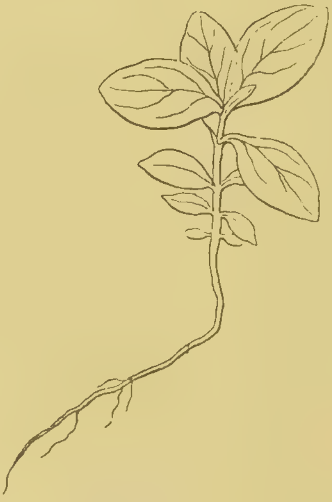

Fig. 207.—*Hypericum Androsæmum.* Nat. size.

except in the tribe Hypericeæ, where they are usually shorter. The radicle is close to the hilum.

Hypericum Androsæmum, *L.* (fig. 207).

Primary root slender, wiry, flexuous, brownish, with few lateral rootlets.

Hypocotyl erect, terete, glabrous, brownish, 3–5 mm. long.

Cotyledons very small, ovate, obtuse, cuneate at the base, glabrous, shortly petiolate; lamina 2 mm. long, 1·5 mm. broad; petiole 1 mm. long.

Stem suffruticose, erect, terete, or slightly two-angled by lines decurrent from the bases of the leaves, glabrous, green or reddish, ultimately brown; 1st internode 1·5 mm. long; 2nd 1·75 mm.; 3rd 2·5 mm.; 4th 2 mm.

GUTTIFERÆ.

Benth. et Hook. *Gen. Pl.* i. 167.

Fruit and Seed.—The ovary of the Guttiferæ varies from two to many cells, except in Calophyllum and Kayea, where it is one-celled and one-ovuled. There is only one ovule in each cell of Tovomita and in the tribe Garcinieæ, otherwise almost without exception the ovules vary from two to many in each cell, and are erect and anatropous, attached to a central placenta or arising from the base of the cavity, with the micropyle inferior. The fruit is fleshy, leathery, or pulpy, and rarely dehisces at maturity except in the tribe Clusieæ, where it splits into valves at the septa. The seeds are large, frequently solitary in each cell, sometimes numerous amongst the species of Clusia, and often enveloped at the base by a lobed or corrugated aril or arillode. The testa is membranous and leathery, rarely spongy as in some species of Calophyllum; in the Mangosteen (Garcinia Mangostana) it is covered with a thick pulpy aril, forming the edible part. Endosperm is wanting.

The embryo is large, filling the seed, to which it conforms: it presents a remarkable and abnormal case, inasmuch as it often consists mainly of a swollen and fleshy radicle with small and scale-like inconspicuous cotyledons at its apex as in the tribe Clusieæ, while they are said to be absent in the

Moronobeæ and wanting or very minute in the Garcinieæ. The radicle is always inferior, and in the Calophylleæ it is very short with large cotyledons sometimes grown together in a mass. In Quiina they are large and fleshy but distinct, while the radicle is very short.

Seedlings.—In the seedlings observed the cotyledons where present are subterranean in germination, and this generally obtains where seeds are large, exalbuminous, and contain a fleshy embryo. The cotyledons of Calophyllum Inophyllum (fig. 209) occupy a large globular seed, and their fleshy petioles are just long enough to allow the plumule to get clear out of the seed. They are also subterranean. The first pair of leaves are reduced to scales, as are also generally the second pair, or these are imperfectly developed. Then follow two pairs of narrowly elliptical, obtuse leaves, after which the seedling stops growing for the season. The penninerved venation is remarkable on account of the dense arrangement of the veins in parallel lines.

Xanthochymus pictorius (fig. 208) and Mesua ferrea agree with the above in all general particulars; but in the former the first four pairs of leaves are reduced to small, ovate, or subulate, black scales, and only one pair of lanceolate acuminate leaves are produced in the first year. The veins of the leaves are parallel but wider apart than in Calophyllum. In Mesua ferrea the first four pairs of leaves are small, scaly, and caducous, followed by two pairs of lanceolate-oblong very finely penninerved leaves, after which growth ceases for a time. When growth recommences the terminal bud is blind, and two axillary branches are developed bearing a single pair of narrower, oblong leaves, and again terminate in a blind bud. The branching is therefore strictly cymose from a very early stage, that is, from the end of the first year's growth of the seedling.

Xanthochymus pictorius, *Roxb.* (fig. 208).

Primary root long, stout, fleshy, yellowish, giving rise to a few strong adventitious roots near the upper end.

Hypocotyl short and merging into the root, subterranean.

Cotyledons subterranean, large, fleshy, filling the large seed and not leaving the testa.

Stem woody, erect, terete, striate, minutely tuberculate, glabrous, deep green; 1st internode subterranean; 2nd 1·9 cm. long; 3rd 2·3 cm.; 4th 3·7 cm.; 5th 2·9 cm.

Leaves simple, entire, cauline, stipulate, opposite, decussate, petiolate, glabrous, penninerved, coriaceous, deep green, with a raised prominent midrib on both surfaces; petioles short, stout, with the flattened midrib occupying nearly the whole of its upper surface and thickened above at the base, covering and protecting the bud, prominently convex on the back, articulated with the stem; stipules small, interpetiolar, triangular.

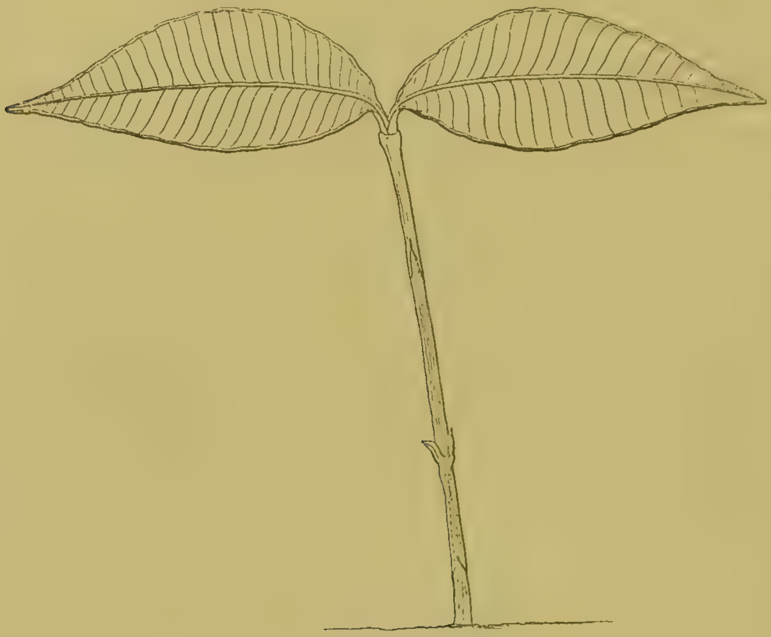

Fig. 208.—*Xanthochymus pictorius*. Half nat. size.

1st to 4th pair of leaves inclusive reduced to small, ovate, or the uppermost subulate, acute, carinate, black scales.

5th lanceolate, elliptic, acuminate, with a prominent midrib and thickened nerve-like margin, 8 cm. long, 3 cm. broad towards the middle.

Ultimate leaves oblong-elliptic, entire, subacuminate, obtuse, penninerved, with parallel veins, deep green, coriaceous, evergreen, stipules small, triangular, interpetiolar.

Calophyllum Inophyllum, *L.* (fig. 209).

Hypocotyl undeveloped.

Cotyledons thick and fleshy, remaining in the testa after germination, shortly petiolate with strong fleshy petioles, subterranean.

Stem erect, somewhat compressed on opposite sides between each internode (the greater diameter being in the plane of the pair of leaves immediately above each internode), glabrous, deep green, more or less mottled with minute colourless dots, ultimately woody; 1st internode 1·4–1·7 cm. long; 2nd 2·5—2·8 cm.; 3rd 4 cm.; 4th 1·8–2 cm.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, densely and alternately or often oppositely and ascendingly penninerved, with slender, parallel nerves, resembling striæ, that run straight and unbranched from the midrib to the margin—rarely do two contiguous ones coalesce close to the margin to form a single nerve—shining on both surfaces, deep green above, light green beneath, hyaline and finely glandular-pubescent at the margin, otherwise glabrous and soon losing the glands; petioles short, stout, glabrous, light green, semiterete, flattened above, slightly thickened at the insertion on the stem.

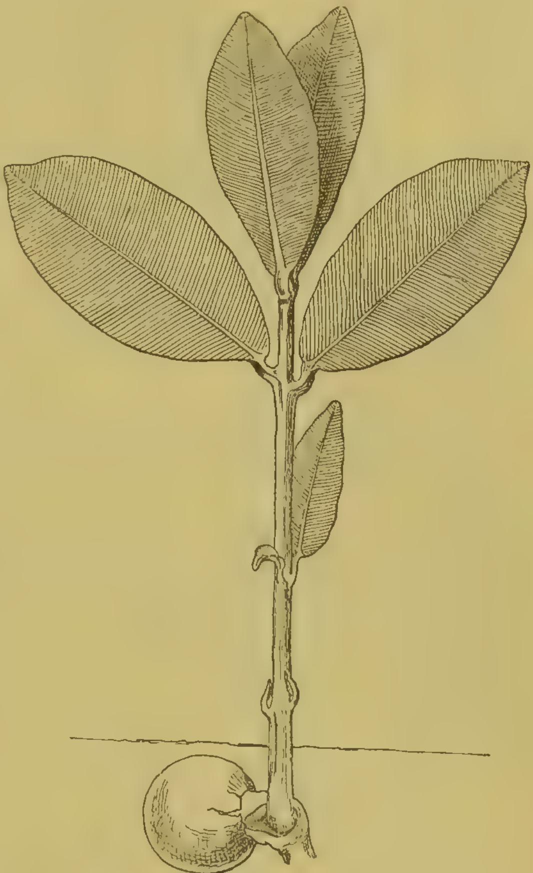
FIG. 209.—*Calophyllum Inophyllum.*
Half nat. size.

1st pair small, scale-like and reduced to their midrib.

2nd pair similar or sometimes much better developed, and sometimes unequal, when the larger one is oblong or oblong-lanceolate and obtuse.

3rd and 4th pairs narrowly elliptical, obtuse, perfect and normal.

Mesua ferrea, *L.*

Hypocotyl subterranean, very short or hardly developed.

Cotyledons large, fleshy, subterranean, and remaining in the broadly amygdaloid seed until they decay.

Stem terete, strong, tapering upwards, glabrous, green, soon becoming woody, brown and striated longitudinally; 1st internode 4·3–4·5 cm. long; 2nd 3·5–3·8 cm.; 3rd 2–2·5 cm.; 4th and 5th about 2·3–2·5 cm.; 6th 2·5–3 cm.

Leaves simple, entire, cauline, opposite, stipulate, petiolate, closely and alternately or almost oppositely penninerved, with the nerves simple or slightly forked and proceeding almost at right angles from the midrib to a slender, continuous, and submarginal nerve, with numerous intermediate, very slender nerves, and finely almost indiscernibly reticulate, coriaceous, glabrous, deep green above, glaucous beneath, with the midrib prominent on both surfaces, evergreen; petioles short, subterete, slightly flattened above or obsoletely channelled, glabrous, furnished at the base with two minute, deltoid, obtuse auricles or stipules, connate around axillary buds.

1st to 4th pairs of leaves reduced to small, caducous scales.

5th and 6th pairs lanceolate-oblong, acuminate, rounded at the base.

Here the stem ends in a blind bud and two axillary buds are developed, which become branches, bearing each a pair of leaves at their apex, ending in a blind terminal bud, and again developing a pair of axillary buds. The leaves on these branches are narrower than those of the stem, oblong, acuminate, obtuse, and rounded at the base.

TERNSTRŒMIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 177.

Fruit and Seed.—The ovary is free, rarely immersed in the torus as in Anneslea and Visnea, generally three- to five-celled except in Ternstrœmia and in a few species of allied genera where it is imperfectly septate. The ovules vary in number exceedingly from two to many in a cell, rarely solitary as in Caryocar, Anthodiscus, Omphalocarpum, Pelliciera, and Haploclathra. They are either erect or horizontal, or pendulous and anatropous, sometimes campylotropous, or laterally affixed and amphitropous with the micropyle superior or inferior. The ovary is two-celled in Pelliciera, many-celled in Anthodiscus, Actinidia and Omphalocarpum. The fruit is fleshy, leathery or almost woody, or a loculicidal or septicidal capsule, the septa often breaking away, leaving a central columella.

The seeds are solitary or more often several or numerous, and attached to axile placentas, which are usually stout and spongy or fleshy; and they also vary exceedingly in size, some being very large as in Ternstrœmia, Caryocar, Pyrenaria, Pelliciera, Camellia, Kielmeyera, and Caraipa. The woody or bony character of the testa is very marked in most of these large seeds; and their variability in shape and in the direction of the longer axis is well seen in Camellia reticulata. Some seeds are more or less winged, as in Pentaphylax, Stuartia, Schima, Gordonia, Laplacea, Kielmeyera, and Marila, in the last of which the wing is fimbriate; while others are fleshy, and probably adapted for dispersion by animals. The endosperm is generally scanty or absent, and this may vary even in the same genus, as in Camellia, for instance, where endosperm is said to be absent. In Camellia theifera it is, indeed, altogether wanting, as well as in Pyrenaria, Gordonia, Laplacea, Caraipa, Pelliciera, Marila, and others. The testa is so thin in Pelliciera as to be almost evanescent. Endosperm is, however, very copious in Actinidia, Saurauja, and Stachyurus. The embryo varies exceedingly; being short and straight, curved, replicate, inflexed, horseshoe-shaped, or spiral, and the cotyledons and radicle also vary in their proportionate lengths, the complications which they undergo, depending greatly upon the shape and other characters of the seed.

The embryo is straight and axile with very short cotyledons in Actinidia, similar or slightly incurved in Saurauja, and straight, nearly equalling the endosperm, in Stachyurus, with elliptic cotyledons; also in Stuartia, where the cotyledons are oval; in Laplacea, where they are oblong and flat; and in Microsemma, where they are ovate and flat. Linear and slender, straight seeds (to which the embryo conforms) occur in Bonnetia, Archytæa, Mahurea, and Marila, but the cotyledons are generally broad and the radicle short. The seeds are without endosperm or almost so, and the embryo is slightly curved in the Marcgravieæ. In the tribe Gordonieæ, to which the Camellia belongs, there is considerable variation in the form of the embryo, for besides Stuartia, Laplacea, and Microsemma mentioned above with a straight and flat embryo, it is nearly flat in Gordonia, or the cotyledons are slightly undulate-plicate, and slightly curved or oblique. This leads to another group in which the cotyledons are folded, plaited, or undulated longitudinally, as in Camellia reticulata. Here the seeds are extremely variable in outline and variously angled by mutual compression, flattened on one side and convex on the other, or flattened on both sides; again they are more or less falcate and drawn out to an obtuse three- to four-angled point, at the opposite end from the hilum, oblong or oblate, with the broadest end always next the placentas. There are two seed-coats, the outer woody or bony, and the inner membranous. The embryo is large, fleshy, straight, colourless, and lies along the longer axis of the seed whether that is at right angles or transverse to the placentas. The cotyledons are oblong, obtuse, somewhat auricled at the base, much plaited longitudinally, lying in the broader plane of the seed, with their edges to the placenta in the oblate seeds, but with the radicle to the hilum or placenta in the long and narrow ones. The seeds in these cases would seem to be amphitropous and anatropous respectively. Schima and Pyrenaria agree with this type in having large embryos and corrugated cotyledons; but the radicle here is long and incurved or inflexed. Pelliciera has broad, thick, and fleshy cotyledons with a straight radicle. The tea-tree (Camellia theifera) offers a remarkable exception amongst its congeners in having a large, fleshy, and globular embryo, with the small radicle and plumule completely surrounded or covered by the hemispherical cotyledons. The radicle of C. reticulata projects considerably beyond the cotyledons. Pelliciera is also remarkable in having a highly evolute plumule.

Hippocrepiform or much curved embryos occur in Visnea, Anneslea, Ternstrœmia, Adinandra, Cleyera, Freziera, Eurya, and Pentaphylax, all belonging to the tribe Ternstrœmieæ. This is due to the seeds, which are curved or horseshoe-shaped, and generally of no great thickness, the cotyledons being semiterete and shorter than the radicle. The elongation of the radicle is carried to excess in Caryocar and Anthodiscus, where the cotyledons are extremely reduced in length and hamato-inflexed. The radicle is of great size, thick, fleshy, and bent or incurved in Caryocar, and very long and spirally coiled in Anthodiscus, with the short cotyledons in the centre of the helix.

Cotyledons.—Very few of this Order are cultivated in gardens, and still less often are they raised from seeds. The Camellia is most common, while Marcgravia and Stuartia are sometimes grown. The cotyledons of Camellia theifera (fig. 210) swell up somewhat during germination, bursting the woody testa, but otherwise do not alter in size and shape. They form a hemispherical mass occupying the interior of the seeds, and are subterranean. They assume more or less of a green colour should they be exposed to light during germination by the bursting of the testa and removal of the soil.

It is probable that the cotyledons of other species and genera are subterranean even after germination, as for instance in the case of Caryocar, Pelliciera, Kielmeyera, and others.

Camellia theifera, *Griff.*

Capsule woody, dehiscing loculicidally, few-seeded.

Seeds large, globose-ovoid, more or less flattened around the hilum, and frequently much flattened on one side by mutual pressure, attached to the axile placentas, and pendulous; seed-coat woody brown, of two layers, the inner, tegmen, of a deep shining chocolate colour; hilum oval, frequently if not always attended by three more or less deep and conspicuous depressions which probably indicate the positions of aborted ovules; raphe (best seen when the inner coat separates from the outer) consisting of a broad trunk proceeding from the hilum close to the upper end of the seed, where the chalaza ramifies extensively and spreads over the testa on both sides of this main trunk; radicle superior, close to the hilum.

Endosperm absent.

Embryo large, fleshy, straight, pale yellowish-white; cotyledons equal and each occupying half the interior of the seed, to the shape of which it conforms, flat on the opposed faces and much rounded on the back in the round seeds, but more or less and variously angled when the seed happens to be compressed on one or more sides; plumule very small, towards the base of the cotyledons; radicle very small, included between their base.

Seedling (fig. 210).

Primary root long, stout, tapering very slightly, becoming woody, colourless, ultimately giving off numerous flexuose and branching rootlets.

Hypocotyl similar to the radicle, but stouter, 1·5 cm. long, 3 mm. thick.

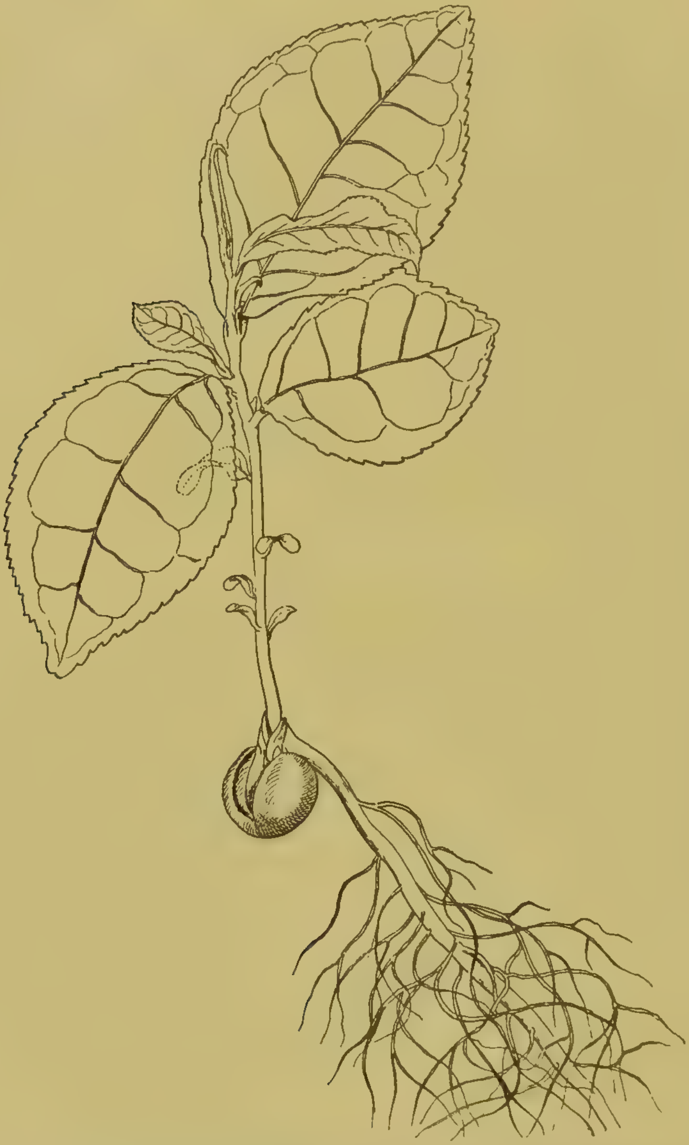

FIG. 210.—*Camellia theifera*, var. Assam hybrid. Half nat. size.

Cotyledons opposite, turned on one side, folded or crumpled, fleshy, and remaining in the testa a long time while the plant gains strength.

Stem erect, terete, woody, pubescent, pale green, becoming brown; 1st internode 1·2 cm. long; 2nd 2·5 mm.; 3rd 6 mm.; 4th

8 mm.; 5th 1·3 cm.; 6th 1·3 cm.; 7th 7 mm.; 8th 8 mm.; 9th 4 mm.; 10th 3 mm.; 11th 4 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, coriaceous, evergreen, glabrous except on the midrib.

Nos. 1 and 2. Oblanceolate, obtuse, 7 mm. long, 3 mm. broad.

Nos. 3 and 4. Spathulate, emarginate, obtuse; largest one 8 mm. long, 5 mm. broad.

No. 5. Obovate, emarginate, 1·6 cm. long, 1 cm. broad, obscurely serrate.

No. 6. Elliptic, obtuse, emarginate, obtusely serrate, with apiculate serratures, 5·5 cm. long, 3·7 cm. broad.

Nos. 7 and 8. Elliptic, subacuminate, emarginate, bullate, serrate, with apiculate serratures; petioles 1·5 mm. long; lamina of No. 7, 7·7 cm. long, 4·5 cm. broad; lamina of No. 8, 8·8 cm. long, 5·1 cm. broad.

Camellia reticulata, *Lindl.*

Capsule large, but short, woody, three- to five-celled, with one or more seeds in each cell, dehiscing loculicidally when mature.

Seeds very variable in outline, and variously angled by mutual pressure, somewhat flattened on one side and convex on the other, or flattened on two sides, more or less falcate in outline and drawn out to an obtuse, three- to four-angled point at the opposite end from the hilum, oblong or oblate, with the broadest end always next the placenta; hilum forming a large scar, linear or oblong, or variously angled in outline, pale coloured; micropyle contiguous to or on the basal scar; seed-coat double; outer (testa) woody or bony, thick, brown, and shining externally; inner (tegmen) thinner, paler, membranous.

Endosperm said to be absent in mature seeds, but in the specimens examined there was an evident though thin layer of fleshy, white endosperm, lining the inner coat of the testa.

Embryo very large, straight, colourless, lying in the longer axis of the seed whether that is transverse or at right angles to the receptacle; cotyledons oblong, obtuse, somewhat auricled at the base, otherwise entire, much plaited longitudinally, lying in the broader and longer axis of the seed, and consequently in the oblate seeds with their edges to the placenta or hilum, and in the long narrow seeds with the radicle next the hilum; radicle short, oblong, stout, obtuse, projecting slightly beyond the auricles of the cotyledons, pointing to the micropyle at the hilum or transversely to it in the oblate seeds.

DIPTEROCARPEÆ.

Benth. et Hook. *Gen. Pl.* i. 189.

Fruit and Seed.—The ovary is generally three-, rarely two- or one-celled as in Ancistrocladus and Lophira, the former having one ascending ovule and the latter eight to twelve erect ovules from a short central placenta. In all other cases the ovules are geminate in each cell, pendulous and anatropous or inserted on the placenta by their sides and subanatropous with a ventral raphe and superior micropyle. Almost the same variability is met with as amongst the Ternstrœmiaceæ. The fruit is free or enclosed in the enlarged persistent tube of the calyx as in Dipterocarpus, two out of the five lobes of which form wings of considerable size, while the other three remain small. A third form is met with in Ancistrocladus, Anisoptera, and Pachynocarpus. The mature fruit contains one, rarely two, seeds, and dehisces very slowly or not at all. The seeds are large, pendulous, and anatropous, rarely erect; they are exalbuminous.

The embryo is always large, and, when the cotyledons are thick and fleshy, it conforms to the seed. It varies greatly, however, in different genera. The cotyledons are equal, or unequal and straight, or lobed and plaited. In some cases they are thin, and in the effort to fill the seed become thrown into remarkably twisted or corrugated folds. The radicle points to the hilum and is slightly exserted, or in other cases elongated, but included between the cotyledons.

CHLÆNACEÆ.

Benth. et Hook. *Gen. Pl.* i. 194.

There are but eight species in this Order, distributed amongst four genera, and all are natives of Madagascar. The three-celled ovary contains two pendulous or in a few cases horizontal anatropous ovules. The fruit is a capsule, nearly always enclosed in an enlarged involucre and three-celled with one or two seeds in each loculus, or one-celled and one-seeded by abortion as in Leptolæna. The seeds are pendulous or attached by the sides, with a coriaceous testa and a fleshy or horny endosperm.

The embryo is straight and embedded in the centre of the endosperm, and has foliaceous, flat or wavy cotyledons.

The Chlænaceæ are small trees, except Rhodolæna, which is a shrubby climber supporting itself on tall trees. The leaves are alternate, generally stipulate, and have a penninerved and reticulate venation.

MALVACEÆ.

Benth. et Hook. *Gen. Pl.* i. 195.

Fruit and Seed.—The carpels vary from two to many, and in most cases are arranged in a whorl around the torus. They are solitary in a few species of Plagianthus, and in Malope, Palava, and Kitaibelia are very numerous, but confusedly arranged over the torus. The ovules are solitary and ascending in each carpel of the subtribes Malopeæ and Eumalveæ, solitary and pendulous in Sideæ, but vary from two to many in the Abutileæ with the exception of Wissadula divergens. They also vary in number in the other tribes. They are very frequently amphitropous, sometimes almost anatropous, and ascending or horizontal with a ventral, lateral, or superior raphe; in other cases they are pendulous with a superior or dorsal raphe.

The fruit is dry, rarely berried as in Malvaviscus, and falls away from the axis as indehiscent or dehiscent cocci, or it is a loculicidal capsule dehiscing by valves. There are a few exceptions in which the fruits are one-seeded and indehiscent, as in Cavanillesia and sometimes in Quararibea and Plagianthus.

The seeds are reniform in the more typical Malvaceæ; but in other cases are subglobose or obovoid. The testa is generally crustaceous, usually more or less wrinkled, and smooth or pilose or covered with long woolly hairs, as in most of the species of Gossypium.

In some of the species of the tribe Bombaceæ the seed has a fleshy or pulpy aril. Endosperm is present or absent, but is generally scanty and mucilaginous ; it is fleshy and plentiful in a few cases only.

The embryo varies according to the character of the seed, reniform seeds having a curved and more or less folded embryo with the back of the cotyledons to the axis, and, as the result of the folding, their edges also. In obovoid seeds the embryo is straight as in the subtribe Fremontieæ, where the cotyledons are flat. In most cases however the cotyledons are foliaceous, of large size, and folded or twisted and plicate, enclosing the radicle. More rarely they are thick and fleshy as in Durio zibethinus.

The radicle in horizontal amphitropous seeds such as those of the Mallow lies in the lower part of the seed, and following the outline of the testa becomes more or less upturned towards the hilum. It is inferior in ascending seeds, and in those that are pendulous it becomes incurved, pointing downwards to the hilum.

The simplest and most typical form of seed and embryo is that seen in Malva sylvestris or Althæa rosea. The seeds are reniform and the embryo conforms to them in general outline ; the tip being involute and lying between the outer parts. The radicle is more or less wrapped round by the base of the cotyledons.

The case becomes more complicated in Gossypium, where the seed is large and globose or angled. The embryo is short, and in making an effort to attain a large size to fill the seed, which contains but a small quantity of endosperm, the cotyledons have grown excessively in width, and in order to accommodate themselves to the shape of the seed, have become greatly folded and plaited, with their bases wrapped round the radicle. Other instances of large seeds and a complicated embryo may be seen in Bombax, Eriodendron, and Pachira.

Seeds containing a straight embryo and flat cotyledons have already been mentioned. In those the radicle is very short.

Seedlings.—The cotyledons of the various types which have come under my notice are nearly all modifications of the same plan; but they may be classified under six headings, namely, cordate, roundly cordate, reniform, ovate, oblong, and transversely oblong.

Malva moschata (fig. 211) may be taken as a good representative of the first group. The cotyledons are slightly unequal in size, cordate, minutely emarginate, obsoletely tri-lobed or -angled towards the apex, and trinerved. The angled appearance is due to the manner of the folding while yet in the seed (see *ante*, p. 41). It is even more distinct in some species than in this. In species belonging to many other genera the cotyledons are merely slightly constricted below the tip instead of being angled. Malva sylvestris, M. rotundifolia, Sidalcea malvæflora, Malvastrum peruvianum, Navæa phœnicea, Lagunaria Patersonii, Abutilon asiaticum, and Eriodendron anfractuosum (fig. 216) agree generally with this type. The last named is notable for the size and persistency of its cotyledons.

Lavatera trimestris differs only in the depth of the apical notch or emargination. In several of the above species there is no apical notch at all. The cordate base is, however, a very persistent character and runs almost throughout the Order. It is due to the manner in which the cotyledons fold round the radicle.

Roundly cordate cotyledons are represented by Hibiscus pedunculatus (fig. 213). One feature here is that one of the cotyledons is inclined to be narrowed to an obsolete blunt point, while the other, generally the larger, is emarginate. Hibiscus Abelmoschus, H. brasiliensis, H. vitifolius, Calirrhoe pedata, Abutilon vitifolium, and Pavonia hastata agree with the above in all important particulars. The bluntness of the cotyledons seems to be due to the size of the seed, and the amount of folding, as seen in Hibiscus Sabdariffa.

The process seems to be carried still further in Hibiscus phœniceus, which represents the reniform type; where the cotyledons have grown more in width than length. Malvaviscus arboreus differs only in being slightly more rounded.

Modiola multifida (fig. 212) has small, ovate, trinerved cotyledons, while those of Sida fallax are larger, and those of Hibiscus Trionum are inclined to be broadly ovate-elliptic. The cotyledons of Adansonia digitata and A. Gregorii are broadly oblong, obtuse, entire, slightly cordate at the base, strongly five- to seven-nerved, somewhat concave and reticulate. Those of Paritium tortuosum are very much smaller with inconspicuous venation.

The transversely oblong type is represented by Gossypium barbadense (fig. 215), in which the cotyledons are large, foliaceous, transversely oblong, retuse, sometimes broadly and shallowly emarginate, strongly three- to five-nerved, and reticulate. G. arboreum agrees, while G. tomentosum sometimes differs in being more or less cuneate at the base. A curious instance of dimorphism occurs in Hibiscus phœniceus. One form of seedling has the first four leaves oblong and tridentate at the apex, followed by four larger and more oval ones. The second form has the first leaf oblong and nearly entire, the second trifid and trinerved, followed by six trinerved and tripartite ones. The leaves from the ninth to the sixteenth inclusive vary with three, four, and five nerves and as many segments, all of which are linear and entire.

In Pachira aquatica the cotyledons are subterranean.[1]

Lavatera trimestris, *L.*

Hypocotyl 12–13 mm. long, erect, terete, glabrous, light green or colourless.

Cotyledons cordate or ovate from a cordate base, unequal, emarginate, obtuse, petiolate, glabrous, green, with a reddish spot near the petiole, very distinctly five-nerved.

Stem with primary internodes undeveloped.

First leaves simple, or roundly reniform, obtuse, cordate at the base, crenate, wrinkled, glabrous, green, pinnately trinerved, petiolate, stipulate; petioles stout, hairy, channelled on the upper side; stipules membranous, brownish, deciduous.

Sidalcea malvæflora, *Lindley.*

Hypocotyl terete, glabrous, fleshy, deep red, 3–5 mm. long, ·5–1·5 mm. thick.

Cotyledons opposite, foliaceous, cordate, entire, obtuse, glabrous;

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[1] Lynch, *Journ. Linn. Soc.* 1878, p. 147.

lamina 11 mm. long, 9 mm. broad; petiole subterete, channelled above, glabrous, reddish, about 1·5 cm. long.

Stem undeveloped.

Leaves simple, radical and cauline, alternate, stipulate, petiolate; stipules subulate.

Nos. 1 and 2. Reniform, crenate, sparsely pubescent on both surfaces, palmately five-nerved, reticulate, rather fleshy.

Ultimate radical leaves cordate-orbicular, coarsely crenate or lobulate with obtuse mucronate teeth, radiately seven- to eleven-nerved.

Cauline leaves gradually developing from the scarcely divided radical leaves, and each becoming more deeply lobed as the top of the stem is approached. Lower ones shallowly radiately lobed; middle ones five- to seven- to nine-lobed or -partite with oblong segments, coarsely and irregularly toothed above the middle; upper ones tripartite, and ultimate ones entire or slightly serrate, lanceolate.

Malva moschata, *L.* (fig. 211).

Primary root normal, tapering, ultimately much branched and fibrous.

Hypocotyl erect, terete, glabrous, pale green, 4–6 mm. long.

Cotyledons somewhat unequal in size, cordate, minutely emarginate, obsoletely tri-lobed or-angled towards the apex, cordate at the base, trinerved, each nerve running into a lobe, glabrous, deep green, petiolate; lamina of larger cotyledon 1·3 cm. long, 1·05 cm. broad, of smaller cotyledon 1·1 cm. long, ·85 cm. broad; petioles semiterete, slightly grooved above, glabrous, that of larger cotyledon ·85 cm. long, that of smaller cotyledon 1 cm. long. Cf. Cruciferæ, tribe Brassiceæ.

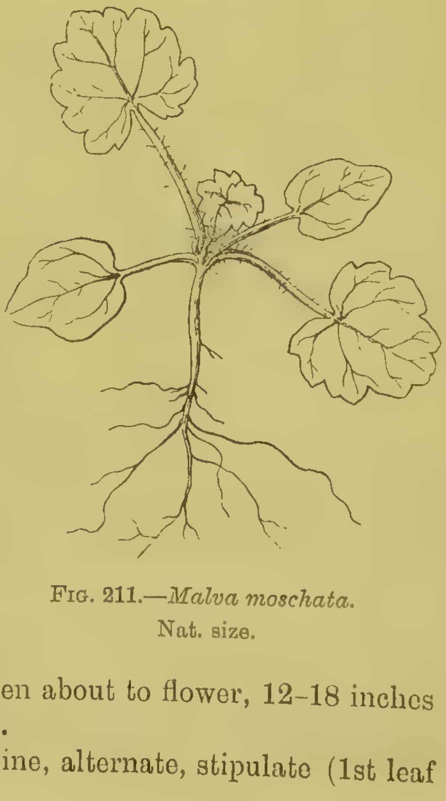

Fig. 211.—*Malva moschata.* Nat. size.

Stem herbaceous, developed when about to flower, 12–18 inches long, ascending, erect or spreading.

Leaves simple, radical and cauline, alternate, stipulate (1st leaf exstipulate), petiolate, deep green, glabrous above, ciliate at the margin, thinly hairy or in young specimens sometimes glabrous beneath; petioles semiterete, channelled above, thinly hairy; stipules subulate, obtuse or subacute, membranous, thinly hairy, whitish in seedlings, absent on first leaf.

Nos. 1 and 2. Reniform, five-nerved, irregularly crenate or incipiently three- to five-lobed.

No. 3. Cordate, more decidedly five-lobed.

Ultimate leaves palmately seven-nerved; radical ones reniform or orbicular with a wide sinus at the base, irregularly crenate or incipiently lobulate; lower cauline ones more or less deeply lobed (generally from one-quarter to one-half their radius); lobes broad, oblong, and again lobulate and subacutely toothed; upper cauline, seven-lobed nearly to the base—larger lobes rhomboid, pinnatifid, and acutely toothed, with alternate ascending nerves.

The cotyledons of M. sylvestris and M. rotundifolia resemble those of M. moschata, but in those I have seen the notch near the apex was somewhat less marked.

Callirhoe pedata, *A. Gray.*

Hypocotyl erect, terete, glabrous, 5–10 mm. long, light green or colourless.

Cotyledons unequal, membranous, rotund-cordate, slightly emarginate, obtuse, cordate at the base, petiolate, with rather long petioles, glabrous, light green, distinctly trinerved.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, petiolate, stipulate, cordate at the base, subrotund, crenate, palminerved, covered with fine hairs; petiole rather thick with a furrow on the upper side; stipules small and deciduous.

Navæa phœnicea, *Webb et Berthelot.*

Hypocotyl erect, terete, pubescent, 2–3 cm. long, light green.

Cotyledons unequal, cordate or elongated, ovate and cordate at the base, subacute, entire, petiolate, covered with minute hairs, green, five-nerved; petiole unequal, channelled on the upper side, hairy.

Stem erect, quadrangular, herbaceous; 1st internode 1–2 mm. long; 2nd about the same length.

First leaves simple, cauline, alternate, stipulate, petiolate, ovate, acute, cordate at the base, coarsely serrate, pubescent, light green, palminerved.

Malvastrum peruvianum, *A. Gray.*

Hypocotyl erect, terete, minutely pubescent, 1·5–2 cm. long, light green or colourless.

Cotyledons cordate, obtuse, unequal, petiolate, entire, glabrous, dark green; venation distinct, pinnatinerved, giving the cotyledon almost a variegated appearance.

Stem, primary internodes undeveloped.

First leaves suborbicular, simple, cauline, alternate, crenate or rather bluntly serrated, petiolate, stipulate, pubescent, light green, pinnatinerved, wrinkled.

Sida fallax, *Walp.*

Hypocotyl suffrutescent, erect, terete, finely pubescent, pale green, 1·5 cm. long.

Cotyledons petiolate; petiole terete, channelled, pubescent, 5 mm. long; lamina broadly ovate, obtuse, pubescent, pale green, 8 mm. long, 8 mm. broad near the base.

Stem suffrutescent, erect, terete, thickened upwards, finely pubescent, pale green; 1st internode 2 mm. long; 2nd 2·5 mm.; 3rd 4 mm.; 4th 8 mm.; 5th 1·25 cm.; 6th 1·4 cm.; 7th 1·3 cm.

Leaves cauline, simple, alternate, stipulate, petiolate, glabrous above, pubescent on the nerves beneath, ciliate; petioles subterete, flattened above, densely pubescent; stipules filiform, slender, hairy, deciduous.

No. 1. Rotund-cordate, coarsely serrate-dentate; limb 1·2 cm. long, 1·1 cm. broad.

No. 2. Cordate, irregularly dentate-serrate, penninerved, or sub-palmatinerved at the base.

No. 3. Rotund-cordate dentate-serrate; nervation like No. 2.

No. 4. Cordate, dentate-serrate.

No. 5. Rotund-cordate, obtuse, coarsely dentate-serrate, more decidedly palmately five-nerved at the base.

No. 6. Similar to last but larger.

No. 7. Rotund-cordate, obtusely dentate-serrate or crenate-serrate, strongly palmately five-nerved at the base, and strongly penninerved upwards with subopposite nerves.

No. 8. Similar, but undeveloped when examined.

Abutilon asiaticum, *Don.*

Hypocotyl soon becoming woody, erect, terete, hairy, and glandular-pubescent, pale green, about 2·2 cm. above the soil.

Cotyledons cordate, obtuse, entire, with long petioles, three- to five-nerved, with a thin glandular pubescence above; margin ciliate with hooked hairs, thinly hairy beneath and glandular-pubescent; lamina 1·25 cm. long, 1·2 cm. broad; petiole 1·3–1·5 cm. long, hairy and glandular-pubescent.

Stem woody, erect, subflexuous, hairy and glandular-pubescent; pale green; 1st and 2nd internodes 2·25 mm. long; 3rd 3 mm.; 4th 2·5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, stellately pubescent on both surfaces, palmately seven-nerved from the first, ciliate, greyish-green above, pale, almost glaucous, beneath, subreticulate; petioles subterete, slightly channelled on the upper side, densely hairy and glandular-pubescent, thickened at the base and also at the insertion of the lamina; stipules small, subulate, hairy, caducous.

Nos. 1 and 2. Rotund-cordate, obtuse, dentate with mucronate teeth.

Nos. 3 and 4. Broadly cordate, subacute, dentate with mucronate teeth.

No. 5. Broadly cordate, subacute, slightly trilobed, dentate.

Pavonia hastata, *Cav.*

Hypocotyl erect, terete, covered with minute hairs, light green or colourless, 1·5–2 cm. long.

Cotyledons fleshy, cordate or rotund, oval, entire, obtuse, unequal (one being much more ovate than the other and cordate at the base), petiolate with hairy petioles and a very few hairs at the base, pinnatinerved.

Stem erect, terete, herbaceous, pubescent; 1st internode 3–4 mm. long.

First leaves simple, cauline, alternate, ovate, obtuse, crenate, slightly cordate at the base, petiolate, stipulate, pubescent, light green, pinnatinerved.

Modiola multifida, *Moench* (fig. 212).

Primary root tapering, flexuous, with lateral rootlets, annual.

Hypocotyl subterranean and tapering indistinguishably into the root.

Cotyledons petiolate, glabrous, somewhat fleshy; petioles channelled above, 5 mm. long; lamina ovate, rather obtuse, faintly trinerved, 4·75 mm. broad, 6 mm. long.

Stem annual, terete, hairy; 1st and 2nd internodes undeveloped; 3rd 2 mm.; 4th 4 mm. long.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, thinly hairy when young, ultimately glabrescent, deep green above, paler beneath; petioles subterete, channelled on the upper side, hairy; stipules free, subulate, acute, broader upwards, hairy.

No. 1. Rotund, crenate, seven-nerved.

No. 2. Reniform, crenate, seven-nerved.

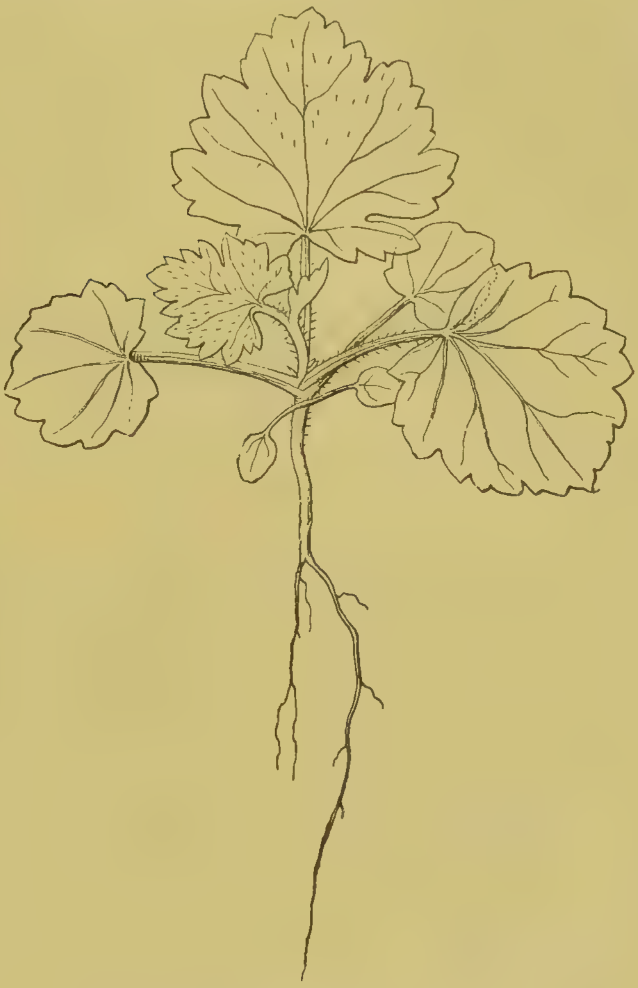

FIG. 212.—*Modiola multifida*. Nat. size.

No. 3. Suborbicular, shallowly cordate at the base, seven- to nine-nerved, deeply crenate.

No. 4. Broadly cordate, nine-nerved, lobulate and crenate.

No. 5. More deeply and decidedly lobed than the last.

Intermediate forms are orbicular, cordate at the base, seven- to nine-nerved, lobed on the upper half, lobulate towards the base, serrate-dentate, with obtuse, apiculate teeth.

Ultimate leaves palmately seven-nerved, with five or seven lobes or ultimately reduced to three; middle lobe rhomboid-oblong, incise-serrate from the middle upwards; lateral lobes oblong, oblique, serrate mostly on the posterior side; basal lobes always small.

Malvaviscus arboreus, *Cav.*

Hypocotyl erect, terete, pubescent, 2·5–4 cm. long, light green or colourless.

Cotyledons reniform or transversely oblong, obtuse, entire or minutely emarginate, cordate at the base, especially the larger one; petiolate, glabrous, light green, palmatinerved; petioles long, terete, pubescent.

Stem erect, terete, herbaceous, pubescent; 1st internode 6–8 mm. long.

First leaves simple, cauline, alternate, ovate, acute, serrate, petiolate, stipulate, pubescent, light green, pinnatinerved; petioles short, terete, pubescent; stipules small, scarious, deciduous.

Hibiscus Sabdariffa, *L.*

Fruit a capsule, five-valved, many-seeded, dehiscing longitudinally.

Seed reniform, subtrigonous like the segment of an orange, somewhat biconvex dorsally, that is, longitudinally and transversely, tapering wedge-like to the ventral edge, glabrous, deep brown, striated longitudinally or following the curvature of the seed; hilum median on the ventral aspect with the remains of the funicle attached to it; micropyle inferior; seed-coat double—outer (testa) thick, coriaceous; inner (tegmen) very thin, paler coloured.

Endosperm scanty, occupying the vacant space about the middle of the seed, on the ventral aspect, and forming an extremely thin layer along the ventral side of the cotyledons and radicle, fleshy, white.

Embryo curved, large, occupying nearly the whole of the seed, yellowish-white; cotyledons cordate-orbicular, slightly trilobate, with deep auricles, emarginate, unequal, reaching the apex of the seed in the course of their growth, then folding at the sides with the edges of both towards the placental axis; at the same time the apex becomes folded or doubled in between the sides and in this way grows nearer to the apex of the seed than the sides do. Nerves five from the base, the two stronger of which proceed to the minute lateral lobes of the cotyledons and are slightly branched; the midrib is alternately branched upwards. Radicle cylindrical, tapered to an obtuse point and curved round the dorsal aspect of the seed, between the auricles of the cotyledons towards the micropyle.

Hibiscus pedunculatus, *Cav.* (fig. 213).

Primary root long, brittle, with fleshy, branched, colourless rootlets.

Hypocotyl about 1·5 cm. long, and a little over 1 mm. thick, terete, slightly uneven, pubescent, bright green.

Cotyledons shortly petioled, ·25–1 cm. long and as broad, broadly cordate at the base, emarginate, otherwise entire, obscurely trinerved, concave, thin, pubescent, including petioles, yellowish-green, not very persistent.

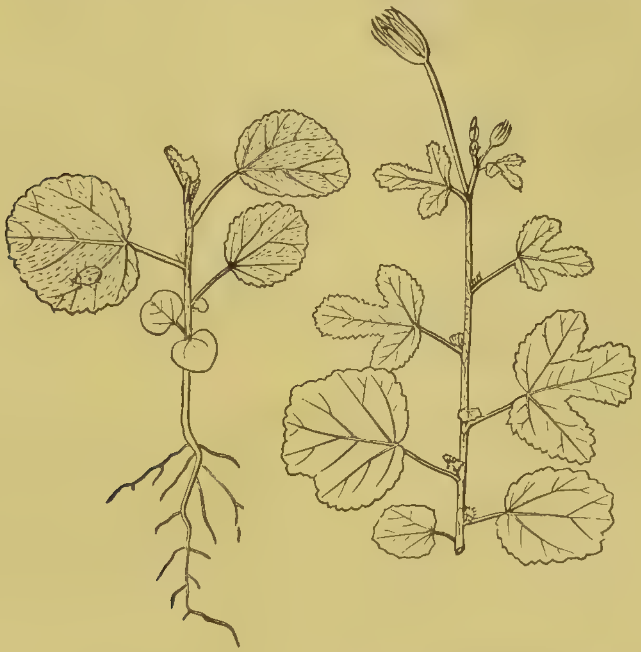

FIG. 213.—*Hibiscus pedunculatus.* Half nat. size.

Stem rather firm, terete, with stellate hairs; first few internodes ·5–1 cm. long, 1·5 mm. thick.

Leaves simple, cauline, alternate, stipulate, petiolate, pubescent all over, crenate in the earlier, and crenate-serrate in the adult leaves, palmately five-nerved from the base with all the principal veins ramified upwards, reticulate; petiole tapering slightly upwards, subterete, pubescent; stipules membranous, small, subulate, acute, deciduous.

No. 1. Rotund-elliptic, crenate, palmately five-nerved.

No. 2. Suborbicular, cordate at the base, crenate.

No. 3. Somewhat similar.

No. 4. Trilobate, crenate-serrate.

Older plants of this species have trifid leaves, but an undivided one at the base of each shoot, and one, two, or more cordate below the trifid ones.

Hibiscus vitifolius, *L.*

Hypocotyl as in H. pedunculatus.

Cotyledons rotund, obtuse, trinerved; lamina glabrous, 1·1 cm. long, 1 cm. broad, truncate or subcordate at the base; petiole subterete, slightly channelled above, pubescent, 8 mm. long.

Stem succulent, erect, terete, pubescent; 1st internode 8–12 mm. long.

Leaves.—No. 1. Rotund or rotund-oblong, irregularly crenate, obtuse, with mucronate crenatures, subcordate at the base, glabrous, ciliate; petiole terete, pubescent, pale green, succulent, about 1·5 cm. long.

No. 2. Rotund-palmate, cordate at the base, shallowly trilobed, irregularly crenate, obtuse, otherwise like No. 1.

No. 3. Rotund, cordate at the base, five-nerved, shallowly trifid, crenate-dentate.

No. 4. Larger, otherwise similar.

No. 5. Broadly cordate, obtuse, seven-nerved, shallowly trifid, crenate-dentate.

Nos. 6–8. Palmately seven-nerved and shallowly three- to five-lobulate, crenate-dentate with obtuse, mucronate teeth, reticulate, stellately pubescent on both surfaces.

Hibiscus Abelmoschus, *L.*

Hypocotyl stout, terete, pale green, suffused with red, covered with a deflexed pubescence, 3 mm. thick and becoming woody.

Cotyledons palmately three- to five-nerved and glabrous, very similar to those of H. pedunculatus; petiole terete, tapering upwards, slightly channelled on the upper side, pubescent, 1·8 cm. long, curved upwards near the apex to bring the lamina horizontal.

Stem terete, pubescent with deflexed hairs, pale green with purple blotches at the axils of the leaves, about 2 mm. thick; 1st internode 1·3 cm. long; 2nd 1 cm.; 3rd ·7 cm.

Leaves cauline, alternate, stipulate, petiolate; stipules small, subulate, deciduous.

No. 1. Palmately five-nerved, obscurely lobed or merely five-angled and crenate, deeply cordate at the base with slightly overlapping auricles, light green above and sparsely pubescent, paler below and pubescent on the nerves ; petiole semiterete, channelled above, tapering upwards, pubescent.

No. 2. Larger, palmately five-lobed and -nerved ; lobes triangular-ovate, basal ones shallow, all obtuse and tipped with a mucro ; otherwise like No. 1.

No. 3. More decidedly palmate, with deeper and narrower lobes than No. 2.

No. 4. Similar to the last but smaller.

Buds are present in the axils of the cotyledons as well as in those of the true leaves.

Hibiscus brasiliensis, *L.*

The seedling closely resembles that of H. Abelmoschus.

Hibiscus Trionum, *L.*

Hypocotyl glandular-pubescent, pale green, 2·2 cm. above ground, 2·25 mm. thick.

Cotyledons rotund, ovate, obtuse, trinerved, glabrous, 1·25 cm. long, 1·1 cm. broad ; petiole subterete, glandular-pubescent, very pale green, 1·1 cm. long.

Stem herbaceous, annual, erect, terete, glandular-pubescent and hairy, pale green ; 1st internode 1·25 cm. long ; 2nd 1·85 cm. ; 3rd 3·4 cm. ; 4th 3·65 cm.

Leaves sparsely pubescent on the nerves and margin, but almost glabrous ; petioles subterete, slightly grooved on the upper side, glandular-pubescent, pale green ; stipules linear-subulate, hairy, caducous.

No. 1. Rotund, crenate, cordate at the base, five-nerved, with ascending and incurved nerves.

Nos. 2 and 3. Similar, but larger.

No. 4. Cordate, obtuse, crenate.

No. 5. Cordate, obtuse, crenate, and slightly lobed on one side, foreshadowing a divided condition of the leaf.

No. 6. Palmately five-nerved and -lobed, cordate at the base ; basal lobes small ; middle lobes subdentate-serrate, oblong ; terminal lobe oblong, broader above the middle, irregularly dentate-serrate from the middle upwards.

Ultimate leaves tripartite ; lateral lobes cuneate-ovate, obtuse, pinnatifid and toothed upwards or almost lobed on the posterior, basal side ; terminal lobe ovate-oblong, cuneate at the base, pinnatifid, with oblong somewhat toothed secondary lobes.

Hibiscus phœniceus, *Willd.*

Hypocotyl pubescent, 11–15 mm. above the soil.

Cotyledons slightly unequal, reniform, emarginate, trinerved from the base with a few alternate nerves upwards, pubescent all over, dull green above, paler beneath; lamina of larger one 10 mm. long, 13·75 mm. wide; petiole of larger one semiterete, shallowly channelled above, slender, pubescent, 5·5 mm. long; lamina of smaller one 9·5 mm. long, 13·25 mm. wide; petiole of smaller one 6·5 mm. long.

Stem erect, terete, closely pubescent, pale green, soon becoming grey, striated longitudinally and woody; 1st internode 5·5–7 mm. long; 2nd 6–8 mm.; 3rd and 4th 10–12 mm.

Leaves undivided or slightly toothed, or more or less deeply three- to five-lobed, and -nerved, somewhat reticulate, pubescent on both surfaces, deep, dull green above, paler beneath, with the midrib and principal nerves more or less stained red on both surfaces, at least at certain stages; petioles subterete, shallowly and narrowly channelled above, tapering slightly upwards, horizontal or ascending, slightly thickened at the base of the lamina, pubescent; stipules linear, hairy, membranous, pale green or slightly stained with red, soon falling away.

Seedlings dimorphic.

(1) More advanced type.

No. 1 leaf. Oblong obtuse, generally with a tooth on each side a little below the apex, rounded at the base.

No. 2. Shortly trifid, with the terminal lobe longest.

No. 3. Deeply trilobed; lateral lobes oblong, obtuse; middle lobe lanceolate-oblong, obtuse.

No. 4. Similar, but segments oblong-linear.

Nos. 5–7. Tripartite, gradually larger, with linear, obtuse segments; middle one longest.

No. 8. Similar to seventh, but there is a small lateral lobe on one side near the base making the leaf four-lobed.

No. 9. Five-nerved and -lobed, with the middle lobe longest, and the basal ones very small.

Nos. 10 and 11. Trilobed.

Nos. 12 and 13. Four-lobed.

No. 14. Five-lobed.

No. 15. Four-lobed.

Nos. 16 and 17. Five-lobed and similar to the ninth.

(2) The second form retains the simpler form of leaf for a much longer period.

Nos. 1–4. Oblong, obtuse, rounded at the base, tridentate at the apex.

Nos. 5 and 6. Similar, but somewhat larger and broader above the base, inclined to be oval.

Nos. 7 and 8. Similar, but with one to two teeth on each side near the apex.

Hibiscus tortuosus, *Roxb.*

Hypocotyl woody, erect, terete, pubescent, pale green, 1·8–2·4 cm. above the soil.

Cotyledons broadly oblong or subcordate, emarginate, deep green, glabrous; lamina 1 cm. long, 8·5 mm. broad; petiole variable in length both in young and adult conditions, pubescent.

Stem woody, erect or subflexuose, terete, pubescent, pale green; 1st internode 2 mm. long; 2nd 1·65 cm.; 3rd 1·4 cm.; 4th 6 mm.

Leaves deep green, glabrous on the upper side, sparsely pubescent on the nerves beneath; petioles terete, faintly grooved on the upper side, pale green, hairy; stipules slender, subulate or linear, obtuse, pubescent.

No. 1. Oblong, subcordate at the base, four-nerved, obsoletely crenate, unequally and obtusely tridentate at the apex.

No. 2. Cordate, obtuse, crenate, four-nerved; nerves ascending and incurved.

No. 3. Similar, but much larger.

Ultimate leaves cordate, acuminate, obtuse, five- to seven-nerved, with a small or obscure lobe on each side above the middle, irregularly crenate-dentate.

Lagunaria Patersonii, *Ait.* (fig. 214).

Hypocotyl erect, terete, pale green, glabrous, 3–4·5 or 5 cm. above the soil.

Cotyledons ovate, obtuse, very nearly or quite equal, obsoletely trilobulate near the apex, subcordate at the base, otherwise entire or minutely emarginate, five-nerved at the base; nerves alternate, ascending, obscurely reticulate, coriaceous, deep green above, paler beneath, glabrous, petiolate; lamina 12·5–18·5 mm. long, 10–16 mm. wide; petioles subterete, shallowly channelled above, slightly pubescent in the furrow, 1–5 mm. long.

In some seedlings the cotyledons are unequal when young, but this inequality seems to disappear when they are fully grown.

Stem erect, terete, densely covered with scurfy, peltate scales, more or less jagged or stellate at the margin, ultimately woody, and arborescent; 1st internode 5–10 mm. long; 2nd 17–20 mm.; 3rd 5–8 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, three- to five-nerved upwards, with incurved nerves, slightly branching and anastomosing within the margin, where the leading ones unite with one another; coriaceous when fully developed, and opaque, with a difficultly discernible venation, deep green above, and closely

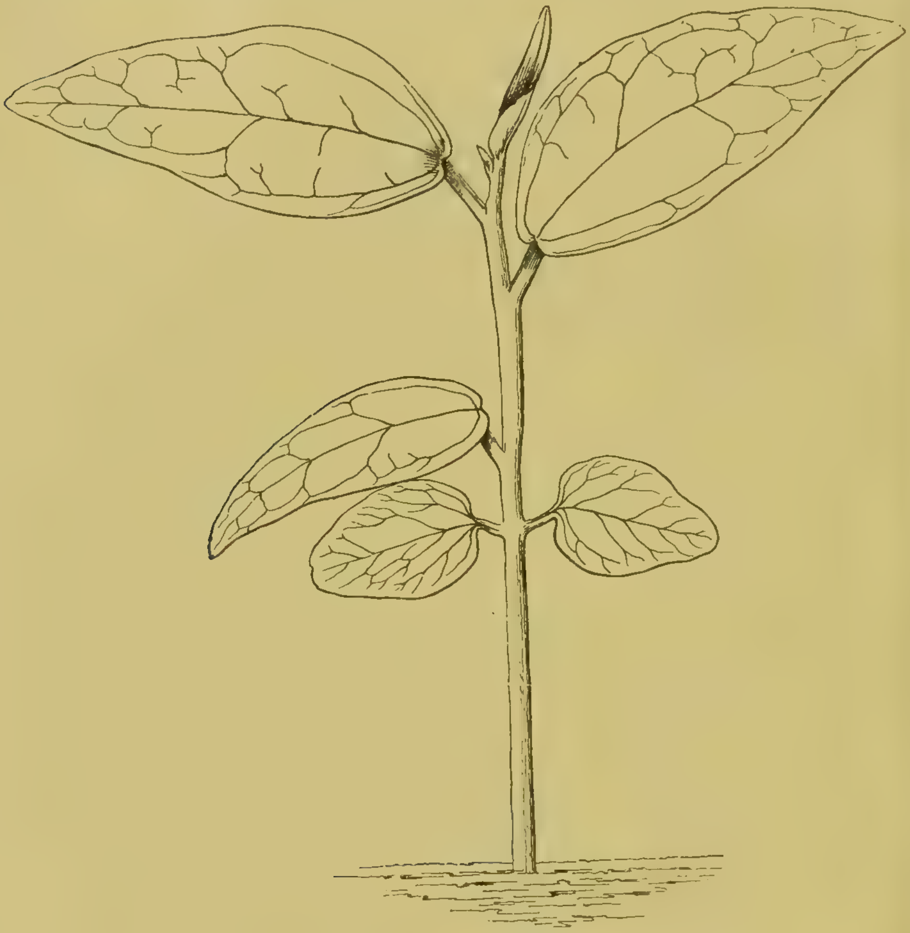

FIG. 214.—*Lagunaria Patersonii.* Nat. size.

dotted, but not covered, with peltate, lacerated, fringed, or stellate scaly hairs, densely felted or tomentose on both surfaces with small scaly hairs and hoary or white; petioles short, stout, subterete, shallowly grooved above, densely felted with stellate, peltate, scaly hairs, tapering slightly upwards; stipules obsolete.

No. 1. Lanceolate, obtuse, trinerved at the base.

Nos. 2 and 3. Ovate, obtuse, three- to five-nerved, slightly cordate at the base.

Gossypium barbadense, *L.* American Upland Cotton (fig. 215).

Hypocotyl 7 cm. long, suffrutescent, erect, terete, sparsely pubescent, punctate with black dots, pale green.

Cotyledons large, foliaceous, transversely oblong, shortly petiolate; lamina three- to five-nerved, punctate with black dots, subemarginate or shortly and very obtusely pointed at the apex, 2·5 cm. long, 4·35 cm. broad.

Stem suffrutescent, erect, terete, hairy, punctate with black dots, pale green; 1st internode 6·8 cm. long; 2nd 1·8 cm; 3rd, 4th, and 5th 1·1 cm.

Leaves simple, cauline, alternate, stipulate, petiolate, five- to seven-nerved and reticulate, hairy on both surfaces and minutely punctate with black dots on the under surface; petioles terete, hairy, pale green, punctate like the lamina; stipules lanceolate, acute, subcarinate, hairy, pale green, and punctate.

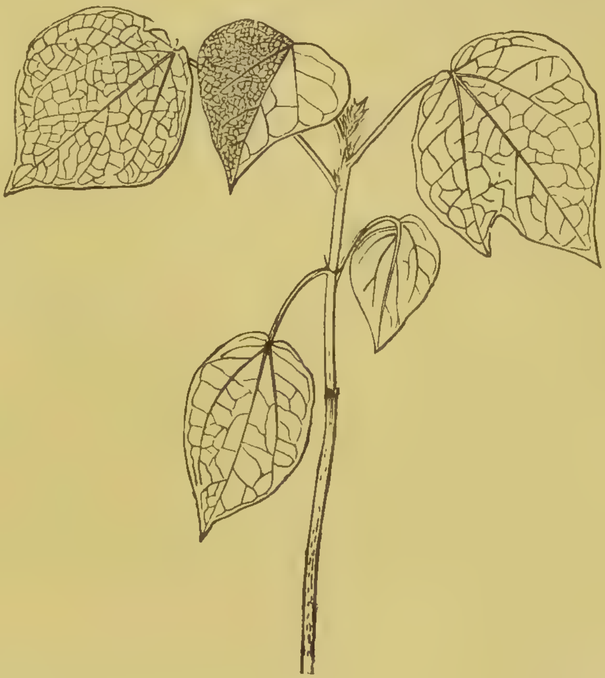

FIG. 215.—*Gossypium barbadense*. One-fourth nat. size.

No. 1. Ovate, slightly acuminate, subcordate at the base, trinerved, entire.

No. 2. Cordate, entire, subacute, suddenly and shortly subacuminate, five-nerved.

Nos. 3 and 4. Palmately five-nerved, trifid, broad, cordate at the base.

No. 5. Similar, but larger and seven-nerved.

Gossypium tomentosum, *Nutt.*

Hypocotyl woody, and closely punctate, with small, black, elevated glands 8·5 cm. long, otherwise as in G. barbadense.

Cotyledons 2·4 cm. long, 3·4 cm. broad, transversely suboval, subcuneate at the base, rather sinuous and almost truncate at the upper edge, palmately five- to seven-nerved, pale green above, glabrous, but closely punctate like the hypocotyl; petiole subterete, slightly channelled above, dilated at the base of the lamina, similarly glandular, 1·5 cm. long.

Stem becoming somewhat woody, erect, terete, pubescent and covered with black dots and glands like the hypocotyl; 1st internode 1 cm., 2nd 9 mm. long.

Leaves.—No. 1. Rotund-cordate, cuspidate, obtuse, subpalmately five-nerved, glabrous, entire, pubescent at the margin, pale green and covered with small protuberances above, paler beneath and covered with black dots; petiole terete, pubescent, tapering upwards, covered with small black glands like the stem; stipules subulate, acute, pubescent, deciduous.

No. 2. Similar to the last.

Adansonia Gregorii, *F. Muell.*

Hypocotyl short, stout, soon becoming woody.

Cotyledons rather persistent, large, foliaceous, broadly oblong, obtuse, entire, strongly seven-nerved from the base and reticulate, concave from the greater growth of the middle portion, petiolate, glabrous, or sparingly ciliated on the petiole; lamina 3·5–3·8 cm. long, 2–2·5 cm. wide; petiole very stout, slightly channelled above, 8–9 mm. long.

Stem erect, terete, soon becoming woody, green, glabrous; 1st internode 3·5 mm. long; 2nd 4 mm.; 3rd 1·8–2 cm.; 4th 2·2–2·4 cm.; 5th longer.

Leaves compound, digitate (1st to 3rd simple), cauline, alternate, stipulate, petiolate, glabrous; stipules subulate, acute, soon becoming brown, deciduous; petioles subterete, slightly flattened above, especially at the base; venation of the leaves ascending, incurved, anastomosing.

No. 1. Oblong, lanceolate, acute, very small and soon withering away, entire.

No. 2. Larger, oblanceolate.

No. 3. Large, palmately tripartite, with a strong rib running into each segment; segments oblong-lanceolate, acute, serrate above the middle.

Nos. 4–7. Digitately trifoliolate; lateral leaflets oblong-lanceolate, acuminate, somewhat oblique on the anterior side, tending to be

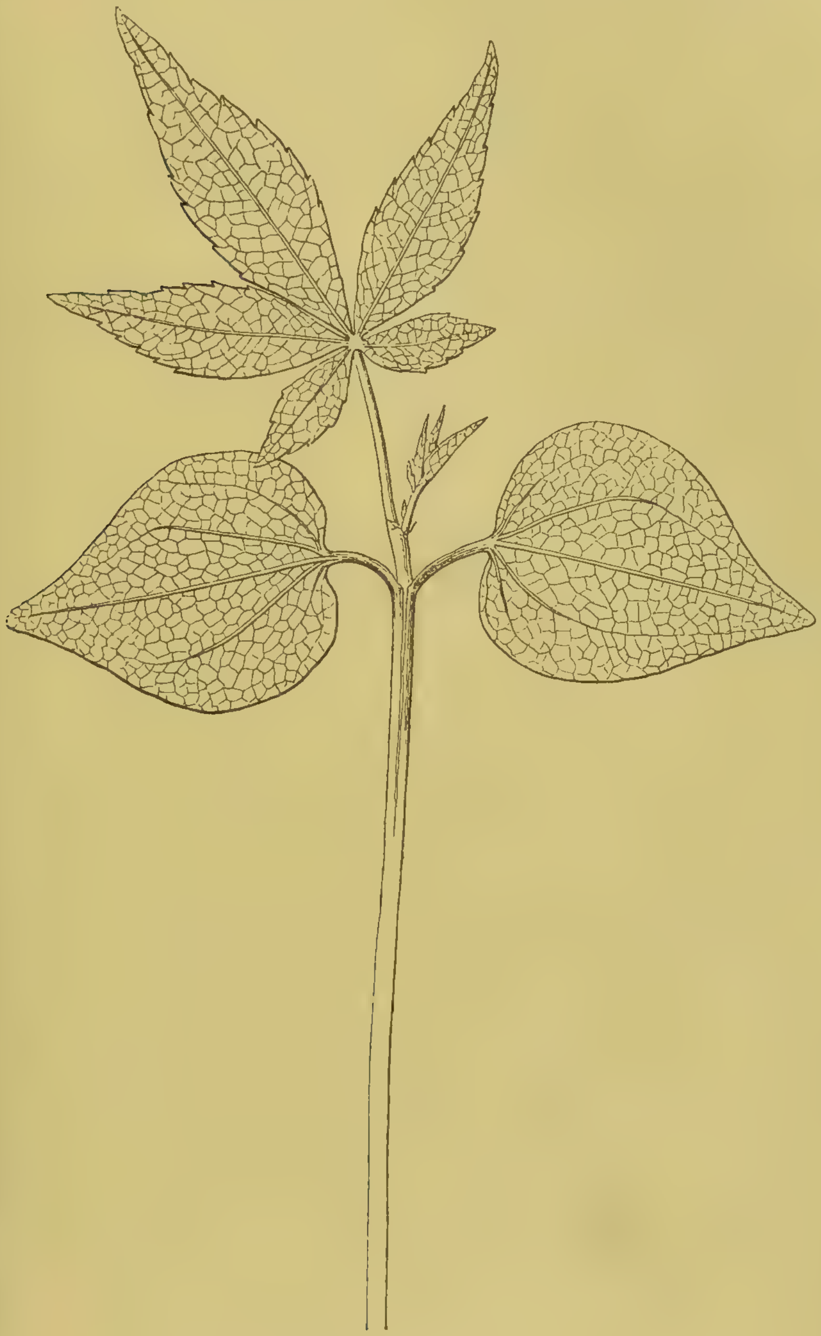

FIG. 216.—*Eriodendron anfractuosum.* Nat. size.

dimidiate, serrate upwards; terminal leaflet oblanceolate, acuminate, serrate above the middle.

Adansonia digitata, *L.*

Hypocotyl stout, short, erect, terete, glabrous, green, 6–8 mm. long.

Cotyledons very large, 4 cm. long by 3·5 cm. broad, broadly or roundly oblong, obtuse, entire, slightly cordate at the base, petiolate, glabrous, green, trinerved with numerous lateral veinlets, petioles thick, scarcely furrowed on the upper side, short.

Stem square, herbaceous, ultimately woody; 1st internode 2·5 cm. long; 2nd 8–10 mm.; 3rd shorter.

First leaves simple, entire; first two lanceolate, acute; others spathulate or cuneate, glabrous, light green, pinnatinerved; petioles short, with the midrib projecting on the upper face; stipules small, acute, brown, deciduous.

The sixth leaf becomes digitate.

Eriodendron anfractuosum, *DC.* (fig. 216).

Hypocotyl erect, 5–8 cm. long, about 2 mm. thick, firm, terete near the base, obtusely four-angled from the middle upwards, glabrous, the lower half brownish-green, lighter above.

Cotyledons long-petioled, about 5 cm. long and nearly 3 cm. broad, subcordate, obtusely acuminate, entire, convex, quite glabrous on both sides, palmately seven-nerved and reticulated in a peculiar, honeycomb-like manner, leathery, dark shining green above, greyish-white below.

Stem terete, firm, about 2 mm. thick, very short, glabrous, yellowish-green.

Leaves.—No. 1. Stipulate, digitate with five divisions; petiole about 3 cm. long by 1 mm. thick, glabrous; divisions unequal, from 1·5–5 cm. long, lanceolate, acuminate, remotely serrate; teeth adpressed; penninerved and reticulately veined, with prominent midrib, glabrous on both sides, somewhat leathery, dark green above, light green below.

Nos. 2 and 3. Similar to No. 1.

STERCULIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 214.

Fruit and Seed.—The ovary is free and syncarpous, but the carpels are frequently only partly united at the base, or so united as to form a two- to five- rarely ten- to twelve-celled ovary. The ovary is however reduced to a single carpel in Waltheria. The ovules vary in number from two to many, rarely solitary, and are (Heritiera) fixed to the inner angles of the loculi, ascending or horizontal, anatropous or amphitropous, with the raphe ventral or lateral, and the micropyle inferior. Exceptions occur in Sterculia fœtida, S. Balanghas, and a few other species, where the ovules are orthotropous with the micropyle superior. The ovule of Heritiera macrophylla is amphitropous, and the radicle superior. The fruit is dry, dehiscing loculicidally, rarely baccate, or woody and indehiscent, or when mature it often breaks up into cocci, indehiscent or with valvular or follicular dehiscence. In Helicteres the carpels are curiously twisted. The seeds are naked or woolly, or embedded in pulp in the baccate fruits; they are often furnished with an arilloid, and sometimes laterally compressed and drawn out into a membranous wing. The testa is coriaceous, crustaceous, or has a fleshy or succulent external covering as in Sterculia; and the endosperm is fleshy and copious, or reduced to a thin stratum, or entirely wanting.

The embryo is large and straight, or bent according to the form of the seed; the cotyledons are generally foliaceous, flat, plicate-corrugate or spirally convolute, more rarely thick and fleshy; the radicle is short, inferior, and pointing to the hilum, except in some species of Sterculia, which have orthotropous ovules and seeds, in Heritiera littoralis, with amphitropous seeds and possibly some others where the radicle is at the apical end of the seed.

Two well-marked types of seeds occur in the tribe Sterculieæ. In Sterculia itself the ovary consists of five nearly distinct two- to many-ovuled carpels, which separate when mature into one-seeded, indehiscent nutlets, as in S. ramiflorum and S. fœtida (fig. 217), or in many-seeded fruits the five carpels form as many rays dehiscing by two valves, or in a follicular manner along the ventral suture only. The fruit of S. ramiflorum consists of five achenes or nuts, densely covered with stalked and stellately-branching hairs. The seed is oblong, and conforms closely to the interior of the nutlet, which it entirely fills. The testa is membranous and creamy yellow; while the micropyle is superior and apical. The endosperm in the mature seed is copious, fleshy, white, and almost separated into two equal halves by the cotyledons; but the halves are connected by a collar encircling the short radicle. The embryo is large, straight or nearly so, axile, and of a dirty yellowish-white. The cotyledons are oblong, obtuse, rounded at the apex, slightly auricled at the base, otherwise entire, equal in length and breadth to the endosperm, except the small portion occupied by the radicle, with their dorsal faces closely applied to the endosperm, and traversed longitudinally by three indistinct nerves and two other short lateral ones near the base. The radicle is very short, stout, embedded between the auricles of the cotyledons, projecting through the endosperm with its tip, and together with the plumule forming a globular mass. From this type S. fœtida (fig. 217) differs only in detail. The nut is bluish-black and glabrous. The cotyledons are oblong or obovate, slightly emarginate owing to a thickening of the chalaza, and surround the plumule and radicle by their bases, leaving only a small opening for the short radicle to protrude; five slightly branching nerves pass upwards from their junction with the hypocotyl. The genus Tarrietia agrees with Sterculia in having the endosperm divided by the cotyledons.

The fruit of Heritiera littoralis consists of one to five obovoid, unequal-sided, shortly stipitate, brown, woody, one-seeded indehiscent carpels or nuts, composed of a dense mass of interlacing fibres, packed with brown cortical matter and laterally compressed, diverging outwards and more nearly in line with the dorsal than the ventral suture. Each nut is about the size of a pigeon's egg. The seed is ovoid, conforming to the interior of the carpel; the testa is brown, thick, and brittle, resembling bark; the raphe ventral, composed of tough fibres, separable from the seed, and extending from near the apex to the base of the cavity of the nut; micropyle superior; endosperm absent. Embryo straight, very large and fleshy, filling the seed, pale pink or flesh-coloured. Cotyledons thick, plano-convex, sometimes slightly wrinkled, frequently if not always unequal, broadly oblong-oval in outline, auricled at the base and embracing the radicle. The largest one is sometimes placed with its back to the ventral, sometimes to the dorsal suture, or irregularly. The embryo is frequently abnormal, assuming various shapes, while the cotyledons are of different lengths, variously twisted and deformed, or they may even be deeply lobed, divided or multiplied, and irregular in size and number. The radicle when normal is short, stout, and grasped by the auricles of the cotyledons, beyond which it does not protrude. The plumule is small and densely covered with short, brown hairs.

The species of Cola and Herrania agree with Heritiera in having exalbuminous seeds and thick cotyledons, but the radicle is close to the hilum. Myrodia has exalbuminous seeds and unequal, conferruminate or amalgamated cotyledons, the larger including or partly enclosing the smaller one.

A third type is presented by Reevesia, in which the seeds have a fleshy endosperm, a straight embryo, and flat foliaceous cotyledons. The seeds are also laterally fixed and produced into a wing on the back. Physodium and Abroma have also a straight embryo, broad, flat, cordate cotyledons, and albuminous seeds; flat, foliaceous cotyledons, and a straight embryo, also occur in Melochia, Dicarpidium, Waltheria, Rulingia, Commersonia, Seringia, Thomasia, Guichenotia, and Lasiopetalum, but the embryo varies considerably in shape both before and after germination.

A fourth type, having exalbuminous seeds and spirally convolute cotyledons, is presented by Kleinhovia and Buettneria, the cotyledons being folded round the radicle, at any rate in the latter. Slightly different from this are those seeds having a thin layer of endosperm, which is even altogether absent in all the species of Helicteres, Eriolæna, and Ayenia. The cotyledons also vary in being convolute or contorted and plicate.

They are corrugate or plicate in Pterospermum, and the seeds are produced into a wing on the top. The seeds are exalbuminous in Theobroma, and the cotyledons are lobed and corrugate. Here also may be placed Guazuma, with albuminous seeds, and a slightly curved embryo with foliaceous, inflexed-plicate cotyledons.

A fifth very distinct type is represented by Hermannia and Mahernia, which have reniform albuminous seeds, with a curved embryo, oblong cotyledons, and the radicle close to the hilum. Taking Pentapetes phœnicea as a type, we find that all of the tribe Dombeyeæ agree with it in having albuminous seeds, foliaceous, bipartite cotyledons, and the radicle close to the hilum. The cotyledons are folded and contorted in Cheirolæna, Trochetia, Pentapetes, and Melhania; they are rarely flat. It seems probable that the species of Ruizia have also bipartite cotyledons. The fruit of Pentapetes phœnicea is a crustaceous capsule, shortly globose-oblong, five-celled, many-seeded, with the anatropous seeds arranged horizontally in two dense rows; dehiscing loculicidally with the valves separating from the plumose midrib. The seed is obovoid, bluntly trigonous or variously angled, and minutely reticulated, with the raphe on the upper side, 2·5 mm. long, 2 mm. wide, and as thick. The endosperm is copious, forming a white layer round the inner face of the seed, while all the rest lying in the middle of the seed and between the folds of the embryo is transparent and mucilaginous, swelling up in water when it becomes white.

The embryo is large, folded, or doubled upon itself a short way above the insertion of the cotyledons. The cotyledons grow till they reach the apex of the seed, then they first become concave on the side towards the raphe (upper side of the horizontal seed), then strongly folded in the same direction. Growth at the apex is then arrested for want of space, but the embryo still grows, and attains a comparatively large size by lateral extension of the cotyledons, each forming two long lobes, which extend round the sides of the seed sometimes in one direction sometimes in the other, so that when mature the cotyledons are deeply bipartite with oblong, obtuse lobes. They are seven-nerved, the midrib being very short, and ending in the sinus, which is the real apex of the cotyledons. A slender nerve is given off from each side of the apex of the midrib and runs up close to the contiguous edges of the sinus; two short lateral ones are also given off from the base; and between the two pairs a strong nerve runs to the apex of each lobe, giving off a few short branches on each side.

A curious case occurs in Hannafordia, containing a single species only. The arilloid of the seed is cut up into numerous segments.

Cotyledons.—The seedlings present four well-marked types—the first, that of Sterculia heterophylla (fig. 218), having large, leathery, foliaceous cotyledons, which are broadly oblong, obtuse at either end, petiolate, five-nerved with a well-marked, reticulate venation, glabrous except the base and petioles, which are shortly pubescent with glandular hairs. The hypocotyl is also shortly pubescent and of moderate length. A considerable number of the Sterculiaceæ conform to this type. Even Hermannia agrees in all the main characteristics except in being much smaller, and in the discernible venation being reduced to an indistinct midrib.

The cotyledons of Heritiera, being large, thick, fleshy, and occupying the whole of the exalbuminous seed, are, most probably, subterranean during and after germination. The conferruminate cotyledons of Myrodia, and the fleshy ones of Cola and Herrania, doubtless correspond with those of Heritiera. A third and well-marked type occurs in the tribe Dombeyeæ, with deeply bifid cotyledons, well represented by Pentapetes phœnicea (fig. 219). The seed-leaves of the latter after germination are deeply bifid with ovate-oblong, obtuse, diverging lobes, five-nerved at the base with two lateral ones given off from the midrib near the sinus, thinly glandular-pubescent at the margin, as well as on the rather slender petioles. The cause to which the fission is due has been described under ‘Seeds.’ A fourth type occurs in Lasiopetalum dasyophyllum and L. ferrugineum (fig. 220). Here the cotyledons are linear, entire, acute, sessile, slightly narrowed to both ends, minutely scaberulous with small elevations, slightly connate at the base, or forming a shallow ridge around the plumule, showing a distinct midrib, but no other venation. From the structure and form of the seed and embryo of the other members of the Lasiopetaleæ they would evidently closely resemble the species of Lasiopetalum in germination.

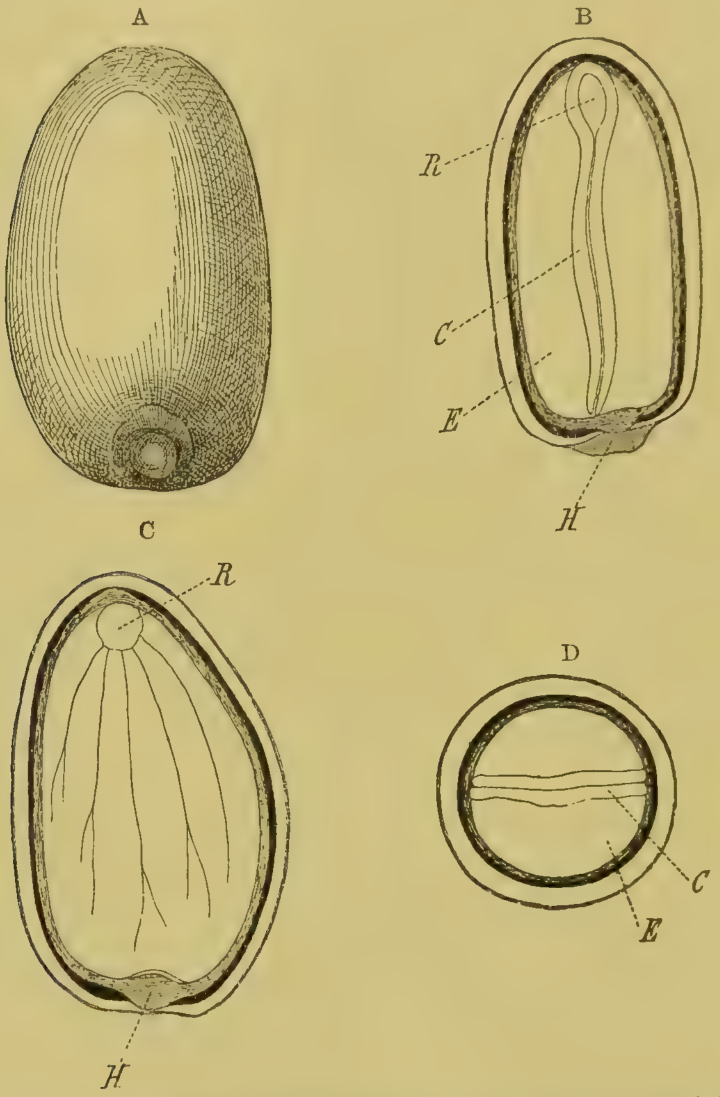

Fig. 217.—*Sterculia fœtida*, × 2. A, ripe carpel or nutlet, one of five forming the fruit. B, longitudinal section of same through the cotyledons. C, longitudinal section in the plane of the cotyledons. D, transverse section: *E*, endosperm; *C*, cotyledon; *R*, radicle; *H*, hilum.

Sterculia fœtida, *L.* (fig. 217).

Fruit of five separate carpels, each oblong, broad and obtuse at both ends, seated on the thickened receptacle, smooth, bluish-black, one-seeded, indehiscent; epicarp thin, membranous, dark-coloured; mesocarp much thicker, corky, brown; endocarp black, hard and crustaceous.

Seed large, oblong, conforming in outline to that of the carpel, basal, erect; testa brown; raphe immersed; chalaza thickened, causing an emargination of the cotyledons; hilum basal in the centre of the cavity of the carpel and attached immediately to the chalaza.

Endosperm copious, fleshy, whitish, divided into two equal pieces by the cotyledons, to which they adhere, resembling two thick cotyledons.

Embryo large, straight, central, equal to the length and breadth of the cavity of the seed; cotyledons oblong or obovate, obtuse, emarginate by the thickening of the chalaza, surrounding the radicle and plumule at the base, and leaving only a small orifice for the radicle to protrude, five-nerved from near the base, with ascending slightly branching nerves; radicle very short, included, stout, close to the upper end of the seed; plumule short, stout.

Sterculia heterophylla, *Beauv.* (fig. 218).

Hypocotyl erect, terete, pubescent with glandular hairs, pale green, soon becoming reddish.

Cotyledons broadly oblong, obtuse and rounded at the end, often truncate or even slightly emarginate, suddenly tapered or almost truncate at the base, petiolate, five-nerved from the base of the lamina, with the nerves incurved at the apex forming a series of intramarginal reticulations, glabrous except at the base, subcoriaceous, deep green above, paler beneath; lamina 2·3–2·6 cm. long, 1·5–1·7 cm. wide; petiole channelled above, convex beneath, pale green, pubescent with glandular hairs, 10–12 mm. long.

Stem erect, terete, pale green or brownish, pubescent with glandular hairs, ultimately woody; 1st internode 3–4 cm.; 2nd 1·3 cm. long.

Leaves cauline, alternate, stipulate, petiolate, alternately, irregularly penninerved, much reticulated, with pale veins and a pale subcartilaginous margin, coriaceous, shining, deep green above, paler beneath; petioles semiterete, channelled above, convex beneath, slightly tapered upwards from a rather stout base, pubescent with glandular hairs; stipules small, subulate, glandular-hairy, pale-coloured, soon becoming dried up and falling away.

No. 1. Lanceolate, acute, entire, small.

Nos. 2–4. Ovate, elliptic, acute or acuminate, entire, gradually becoming larger.

Cola sp.

Primary root long, tapering, stout, giving off few or no lateral rootlets in the young state.

Hypocotyl very short and indistinguishable from the root, or undeveloped.

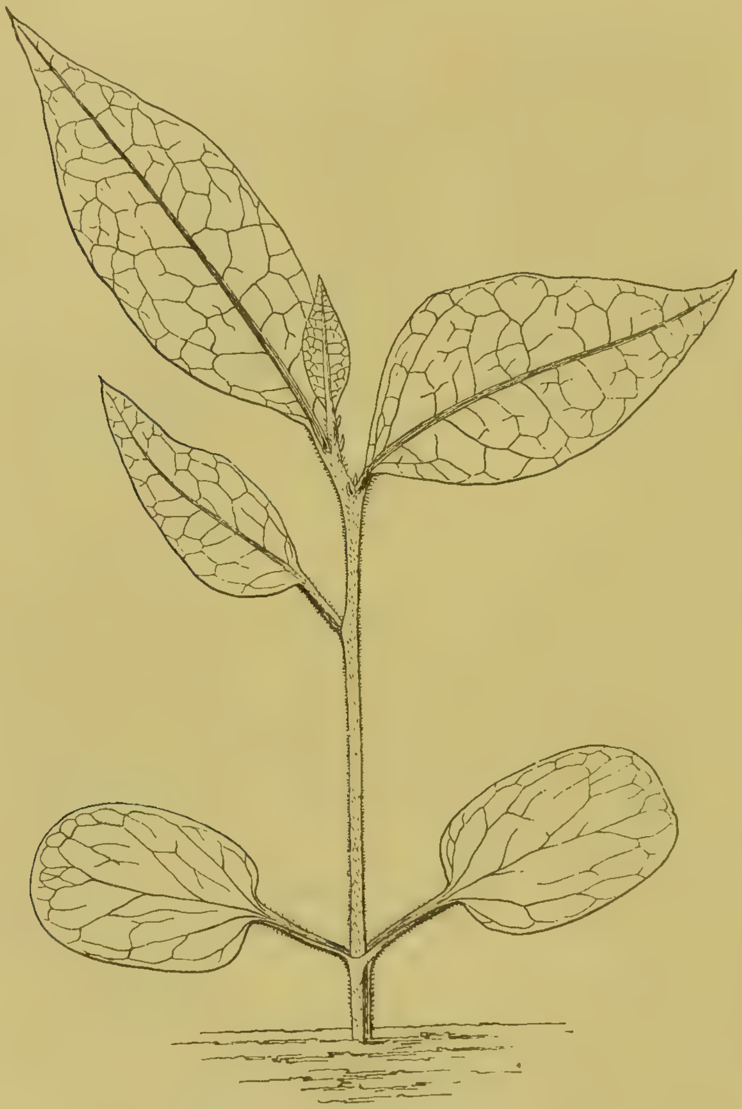

Fig. 218.—*Sterculia heterophylla.* Nat. size.

Cotyledons four, each forming the quadrant of an oblong-spherical mass, fleshy, very large, occupying the seed and subterranean during germination, white if left uncovered, or pink, reddish, or deep green according to exposure to light, petiolate. Each of the four cotyledons has a roughly trigonal outline owing to mutual pressure, and each is emarginate or auricled at the base with the auricles more or less closely applied to one another while in the seed and hardly separating during germination. Petioles terete, rather slender (compared with the lamina), 12–14 mm. long and attached to the inner face of the laminæ about 5–7 mm. above their base, that is at the upper end of the fissure between the auricles.

Stem erect, stout, woody, more or less scaly, at least in the young state.

Leaves alternate, stipulate, cauline, penninerved, scaly, petiolate.

Nos. 1 and 2. Opposite or subopposite, scaly, brown.

Nos. 3 to 6. Alternate and similar.

No. 7. Ovate, foliaceous, penninerved.

Heritiera littoralis, *Ait.*

Fruit of one to three, rarely four to five, obovoid, unequal-sided, shortly stipitate, brown, rough, woody, one-seeded carpels, composed of a dense mass of interlacing fibres packed with brown corky loose matter, and ending in a stout curved beak, which is laterally compressed, diverging outwards and much more nearly in line with the dorsal than the ventral suture. Hence the ventral side of the fruit appears almost ventricose.

Seed roughly obovoid and conforming to the interior of the carpel; testa brown, thick, brittle, resembling bark; raphe ventral, composed of tough fibres separable from the seed, extending from near the apex to the base of the cavity of the carpel; micropyle superior; hilum large, oblong, ventral, below the apex and extending downwards.

Endosperm absent.

Embryo straight, when mature very large, fleshy, filling the whole interior of the seed, pale pink or flesh-coloured; cotyledons very thick, plano-convex, slightly wrinkled or uneven, sometimes furrowed along the back of the midrib, frequently if not always unequal, oval or oblong-oval in outline, but often assuming various shapes, auricled at the base and embracing the radicle. The largest cotyledon is sometimes placed with its back to the ventral suture, sometimes to the dorsal suture or irregularly. In some instances the cotyledons are of different lengths or variously twisted and deformed or even multiplied, and irregular in size and number.

The radicle when normal is stout, very short, grasped by the auricles of the cotyledons, beyond which it does not protrude; it is superior.

Plumule small, densely covered with short brown hairs.

Pentapetes phœnicea, *L.*

Fruit a capsule, shortly globose-oblong, five-celled, many-seeded, with the seeds arranged horizontally in two rows, dehiscing loculicidally from base to apex, separating from a plumose nerve (the midrib of the carpel); epicarp crustaceous, brown; endocarp thinner, membranous, pale.

Seed obovoid, subtrigonous or variously angled, minutely reticulated; seed-coat double; outer (testa) crustaceous, brown; inner (tegmen) thin, pale; micropyle and hilum basal; chalaza apical; raphe on the superior side of the horizontal seed, facing the apex of the ovary. Seed 2·5 mm. long, 2 mm. broad, and 2 mm. thick.

Endosperm copious, forming a white layer round the inner face of the seed, while all the rest lying in the middle of the seed and between the folds of the embryo is transparent and mucilaginous, swelling up in water, when it becomes white.

Embryo large, folded or doubled upon itself, definitely in the lower half, but somewhat indefinitely above; cotyledons deeply bifid, growing till they reach the apex of the seed, when they become first concave on the side towards the raphe (upper side), and then strongly folded in that direction. Growth at the apex is here stopped for want of space, but the embryo continues to develop and is able to attain a much larger size by lateral extension of the cotyledons round the sides of the seed, sometimes in one direction, sometimes in another, producing the oblong lobes above mentioned. The venation consists of five nerves, the middle one of which is very short and ends at the apex, giving off a slender nerve up each side of the apical sinus; the two nerves, one on each side of the midrib, are the strongest and run to the apex of the lobes; the lateral nerves are very short and not very conspicuous. Radicle straight, oblong, obtuse, occupying the greater part of the length of the seed.

Seedling (fig. 219).

Hypocotyl erect, terete, thinly glandular-pubescent, pale green, 2·5–4·5 cm. long.

Cotyledons petiolate; lamina deeply bifid with ovate, obtuse, diverging lobes, each binerved, while the midrib forks in the sinus, thinly glandular-pubescent at the margin, pale green; petiole semi-terete, shallowly grooved above, thinly glandular-pubescent, 4–7 mm. long; lamina 8–12 mm. long, 8–10 mm. broad.

Stem herbaceous, erect, thinly glandular-pubescent, pale green; 1st internode 6 mm. long; 2nd 1·75 mm.; 3rd 1 mm.

Leaves simple, cauline, alternate, stipulate (1st leaf exstipulate !), petiolate, glabrous or nearly so; petioles semiterete, slightly grooved above, thinly hairy; stipules small, subulate, obtuse, glandular-pubescent.

No. 1. Obovate-cuneate, obtusely serrate with aristate teeth, five-nerved at the base.

Nos. 2 and 3. Rhomboid-ovate, serrate, with aristate teeth; five-nerved at the base and alternately nerved upwards.

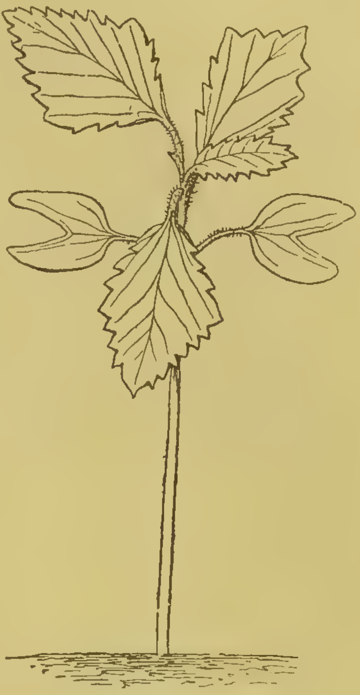
FIG. 219.- *Pentapetes phœnicea.* Nat. size.

Hermannia cuneifolia, *Jacq.*

Hypocotyl erect, terete, minutely pubescent, 7–12 mm. long, light green or colourless.

Cotyledons oblong, obtuse, entire, petiolate, glabrous, dark green, fleshy, indistinctly one-nerved.

Stem erect, terete, herbaceous, pubescent; 1st internode 1·5–2 mm. long.

First leaves simple, cauline, alternate, obovate, obtuse, crenate near the apex, petiolate, stipulate; stipules deciduous, pubescent, light green, pinnatinerved.

Lasiopetalum dasyophyllum, *Sieb.*

Hypocotyl erect, terete, soon becoming brown, 1·1–2·2 cm. long.

Cotyledons linear, entire, acute, sessile, slightly narrowed at both ends, showing a distinct midrib but no other venation, glabrous, minutely scaberulous, bright green above, paler beneath, slightly connate at the base around the plumule, 15–30 mm. long.

Stem erect, somewhat obtusely angled, minutely glandular-pubescent, scaberulous, pale green, becoming brown; 1st internode about 2·5 mm. long; 2nd 1·25–1·5 mm.; 3rd 5 mm.; 4th 9·5 mm.; 5th and 6th about 1·4–1·6 cm.

Leaves simple, cauline, alternate, exstipulate, petiolate, alternately incurvinerved, glabrous, scaberulous on the upper surface with small, glandular elevations, shiny when young, bright green above, paler and shiny beneath; stipules apparently obsolete; petioles extremely short or almost none, while the leaf is so much narrowed towards the base as to resemble a petiole.

Nos. 1–3. Cuneate-obovate, obtuse, serrate or dentate along the apex, gradually tapering or cuneate at the base, where it is more or less glandular-dentate, with small or minute teeth.

No. 4. Narrowly obovate-cuneate, much narrowed at the base, irregularly dentate near the apex, minutely so below.

Nos. 5 and 6. Oblong or lanceolate, obtuse, with a few large teeth, or minutely dentate only.

No. 7. Linear-lanceolate, obtuse, tapering to both ends, but especially to the base, slightly revolute at the margin as is the one below it, but more especially the younger ones above, which gradually become narrower and more elongated.

Lasiopetalum ferrugineum, *Sm.* (fig. 220).

Hypocotyl erect, terete, more or less scabrous, soon becoming brown and losing its epidermis by splitting in longitudinal fissures.

Cotyledons tapering to a narrow base and forming a very slender line around the first and somewhat thickened node, not very distinctly petiolate, slightly channelled above, 1·7–2·4 cm. long, 1·5–2·5 mm. wide, otherwise as in L. dasyophyllum.

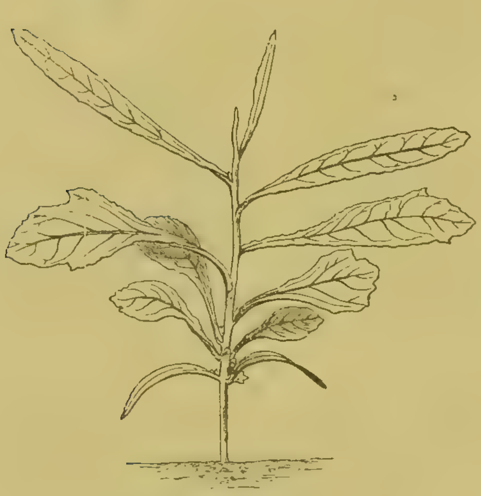

Fig. 220.—*Lasiopetalum ferrugineum.* Half nat. size.

Stem as in L. dasyophyllum; 1st internode 2–8 mm. long; 2nd 1–6·5 mm.; 3rd 1–12·5 mm.

Leaves as in L. dasyophyllum; petioles very short, channelled above, gradually becoming shorter, as the leaves develop, from the first one upwards.

Nos. 1–4. Obovate-cuneate, tapering to a long base, variously and obtusely dentate along the obtuse apex.

No. 5. Rhomboid or cuneate, variously and obtusely dentate for the greater part or the whole of its length, tapering much to the base.

No. 6. Spathulate, obtuse, tapering to a long base, with one to two coarse teeth at the apex and small ones throughout the greater part, or at the base only.

Nos. 7–9. Linear, obtuse or cuspidate, gradually tapered to the base and minutely toothed throughout or subcrenate.

TILIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 228.

Fruit and Seed—The ovary in the Tiliaceæ is superior, syncarpous, two- to ten-celled. The ovules are solitary or geminate in each cell, inserted at the inner angle, and pendulous from the top, or ascending from the base; sometimes the ovules are few, attached to the middle of the placenta and ascending or pendulous, or in other genera they are numerous and arranged in two to many ranks, anatropous or subanatropous with the raphe ventral or lateral. An abnormal form occurs in Sparmannia, where the ovary is half inferior, and almost one-celled by the abortion or suppression of the septa. The carpels are nearly free in Christiana and Brownlowia. The fruit varies in different species from two- to ten-celled, or may be one-celled by abortion; sometimes the loculi are spuriously divided by longitudinal or transverse divisions developed between the seeds. When mature it is a nut as in Tilia, a drupe as in Grewia and Elæocarpus, or a berry as in Aristotelia and Muntingia. In all these cases it is indehiscent; but in Columbia it divides or splits into cocci, or it is capsular and dehisces loculicidally, more rarely septicidally as in Dubouzetia.

The seeds vary from one to many in each cell and are ascending, pendulous, or transverse. The testa is leathery, crustaceous, and smooth or densely hairy or pilose as in Berrya, Carpodiptera, and at the margin only in Belotia: in certain genera it is thickened and hardened at the chalaza as in Tilia, Berrya, and others. The endosperm is fleshy and copious or thin, very rarely entirely absent as in Brownlowia. The embryo varies, but is generally straight, with ovate or roundly-cordate foliaceous rarely fleshy and almond-like cotyledons; and a short radicle, rarely longer than the cotyledons, close to the hilum.

The seeds may be roughly divided into four groups according to the form and other characters of the embryo. The first group has fleshy or almond-like cotyledons as in Brownlowia, in which endosperm is absent. Others in this category are Sloanea and Prockia. The radicle in Prockia is longer than the cotyledons, and the latter are very small in Muntingia, continuous with, and scarcely broader than, the thick and fleshy radicle.

A large number of genera have a copious endosperm surrounding a slightly shorter embryo with broad, foliaceous, and ovate or rotund-cordate, straight and flat cotyledons which are foliaceous in germination. This group would include Christiana, Columbia, Erinocarpus, Triumfetta, Heliocarpus, Honckenya, Luhea, Glyphæa, Apeiba, Echinocarpus, Tricuspidaria, and others. There is, however, some variation even in the same genus, as in Elæocarpus and Aristotelia, the cotyledons of which are flat in some species and undulate in others. These latter lead to a third group in which the embryo is not entirely flat but has the cotyledons variously curved or bent. Berrya Ammonilla may be taken as a type of this group. The seed is obovoid, pale brown, much thickened and black at the chalaza, and contains a copious, colourless endosperm, which becomes white and swollen when steeped in water. The cotyledons are obovate or orbicular in different seeds and deeply cordate at the base, including the hypocotyl in the notch, five-nerved from the base, the nerves giving off smaller branches; from being longer than the endosperm they are sharply curved or bent to one side below the apex. They are, however, otherwise flat, closely adpressed face to face till they come in contact with the thickening of the chalaza, when they bend towards the dorsal aspect of the seed. The hypocotyl and radicle together are about twice the length of the blunt auricles of the cotyledons, beyond which they project. A transverse section of the seed shows that the cotyledons are sometimes at least slightly incurved so as to be concave along the median line. Several others may be placed in this group inasmuch as the embryo is more or less bent. Entelea has the cotyledons nearly flat and the radicle inflexed or but slightly bent; the embryo of Sparmannia is plicate or nearly flat and straight; in Corchorus it is incurved; and in Schoutenia the margins of the cotyledons are involute.

The above are scattered through different tribes, several of them belonging to the Tilieæ, in which the extreme limit of comparative size and complication is met with in the genus Tilia itself, which may be taken as the type of a fourth group. The ovary is five-celled with two ovules in each cell, but as it matures into fruit, one seed generally takes the lead, outgrowing all the others, which, together with four out of the five cells of the ovary, remain small and get crushed on one side. The fruit is an indehiscent nutlet, with one, rarely two seeds; the latter are obovoid or subglobose, deep brown, and have the testa thickened at the chalaza. The endosperm is copious, fleshy, pale yellow, or nearly white. The embryo is at first obtusely ovate, with entire undivided cotyledons, which as growth goes on become deltoid and subpalmately five-lobed. When the apex comes in contact with the testa in the chalazal region of the seed, the cotyledons bend and then become folded or doubled upon themselves with the loop of the fold sharply deflected on the ventral aspect. The terminal lobe then grows in the opposite direction, and curves round the apex of the seed, with the tip so nearly exposed as to be quite visible through the endosperm. The two pairs of lateral lobes reach the sides of the seed, and become curved round it to the dorsal aspect, where their tips also become quite visible through the endosperm. The lobes are narrowly ovate, obtuse, and each has a strong median nerve running through it; the lower pair springs from the base of the lamina, while the pair above them arises from the side of the primary nerve; the basal pair and the terminal lobes are considerably larger and longer than the middle pair. The hypocotyl and radicle are cylindrical and obtuse or somewhat clavate. The above characters have been taken from T. vulgaris (fig. 223, which shows the form of the embryo separated from the endosperm). T. petiolaris differs only in minute particulars; a section of the fruit shows (fig. 224) the relative position of the embryo and seed to the fruit; the embryo as a whole is less folded than in T. vulgaris. The basal and terminal lobes of the cotyledons are shorter, blunter, and more rounded, while the median pair is relatively very small. The median nerve of the latter sometimes arises from the base of the lamina, in which case the venation and divisions are truly palmate.

The folding of the various parts of the embryo is easily accounted for, since it grows too large to lie flat in the seed. An indication of this condition is seen in Berrya Ammonilla, where the cotyledons become slightly curved at the apex, while in Schoutenia they are involute at the margin. This is precisely what happens in Tilia, and the differences consist in the larger embryo, the greater amount of folding, and above all in the division of the cotyledons into five lobes. The only apparent reason for the lobing is to facilitate folding, not only at the apex, but all round the sides. The seed being obovoid or globose, the embryo assumes the form of a half-closed fist in order to accommodate itself to that shape.

Cotyledons.—The cotyledons may be grouped under four headings, namely, obovate, ovate, lanceolate or oblong-lanceolate, and lobed. The first type is seen in Berrya Ammonilla (fig. 221), which has rotund-obovate, obtuse cotyledons, suddenly tapered into the petiole, five-nerved, reticulate, glabrous except on the principal nerves and the petiole, which are finely pubescent. The hypocotyl is also similarly pubescent—not a common occurrence. Before germination they vary according to the shape of the seed from obovate to orbicular with a deeply cordate base, but subsequently lose the latter peculiarity, as in many or most of the Labiatæ and in Cuphea among the Lythrarieæ.

Ovate cotyledons are more common, perhaps the commonest form in the Order. Those of Corchorus olitorius (fig. 222) are ovate, obtuse, five-nerved at the base, subfleshy, glabrous except the petiole, which is occasionally thinly pubescent like the hypocotyl. Those of C. capsularis differ in being broadly or rotundly ovate and, sometimes at least, turned to one side of the stem, which would indicate a tendency to become fleshy and functionless, except as a storehouse for reserve-material. Aristotelia racemosa agrees more nearly with Corchorus olitorius except in being membranous, indistinctly nerved, and glabrous.

In some species of Elæocarpus the cotyledons after leaving the seed grow to a considerable size. Those of E. oblongus (fig. 226) are oblong-lanceolate, obtuse, very shortly petiolate, trinerved in the lower half, reticulate, subcoriaceous, glabrous, with red veins, very persistent like the true leaves, about 6 cm. long, and 2·5 cm. wide at the base. Those of

E. cyaneus are also foliaceous, but much smaller, lanceolate, obtuse, opaque, coriaceous, obscurely penninerved and reticulate, 1·9 cm. long, and about 7·25 mm. broad; the petiole is only 1 mm. long.

The fourth type is that of Tilia vulgaris (fig. 223) and others of the same genus. The cotyledons of the former after germination are foliaceous, rhomboid-subtriangular, five-lobed, five-nerved at the base with the two lower pairs of nerves running into the basal pair of lobes, alternately nerved upwards with two strong nerves running into the middle and small pair of lobes, thinly pubescent on both surfaces, 1·5–2·1 cm. long, and 1·7–2·5 cm. from tip to tip of the basal pair of lobes; the petiole is rather slender, semiterete, and pubescent. Occasionally three perfect cotyledons occur, and, corresponding exactly in shape to those of normal seedlings, indicate that the 5-lobed character is of long standing and has become thoroughly fixed by heredity; otherwise if they depended directly upon the conformation of the seed for their peculiar shape, the presence of three would have caused some modification of the normal type.

The Tiliaceæ include some 330 species, dispersed over the whole world, most numerous within the tropics of both hemispheres, less so in temperate regions both north and south of the equator.

Berrya Ammonilla, *Roxb.*

Fruit a capsule, subglobose, three-celled, each cell one- to two-seeded; dehiscing loculicidally by three valves.

Seed obovoid, glabrous, pale brown and often with darker brown stripes from the hilum upwards; seed-coat double—testa thin, membranous, easily separable from the tegmen which is much thicker, crustaceous, deeper brown, much thickened and hardened at the chalaza where it is nearly or quite black; micropyle and hilum contiguous, basal; raphe ventral, separable from the testa; chalaza apical.

Endosperm copious, colourless, and shrunk away from the dorsal aspect when dry, white when moist.

Embryo central, curved or bent above the middle owing to its being slightly longer than the endosperm, pale yellow; cotyledons cordate-orbicular, five-nerved from the base, with a few short alternate nerves proceeding from the midrib, broad, flat, closely adpressed face to face, straight until they come in contact with the thickening at the chalaza, when they bend towards the dorsal aspect of the seed; auricles rounded, obtuse; radicle stout, oblong, obtuse, about twice as long as the auricles of the cotyledons, with its tip embedded in the endosperm close to the micropyle.

Seedling (fig. 221).

Hypocotyl erect, terete, densely and finely pubescent, pale green, 1·8–2·1 cm. above the soil.

Cotyledons rotund-obovate, obtuse, entire, suddenly tapered into the petiole at the base; five-nerved and reticulate, glabrous except on the principal nerves and the petiole, which are pubescent, light green; lamina 10–13 mm. long, 9–11 mm. broad; petiole semiterete, flattened above, densely pubescent, 2·5–3 mm. long.

Stem erect, terete, densely and finely pubescent, pale green, ultimately woody; 1st internode 4–5 mm. long; 2nd 4–6 mm.; 3rd 5–7 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, five- to seven-nerved and reticulate, light shining green, pubescent on the nerves on both surfaces; petiole terete, tapering upwards from a rather stout base, densely pubescent, pale green; stipules small, subulate, slender, green, deciduous, inserted at the very base of the petiole of the leaf or on the stem.

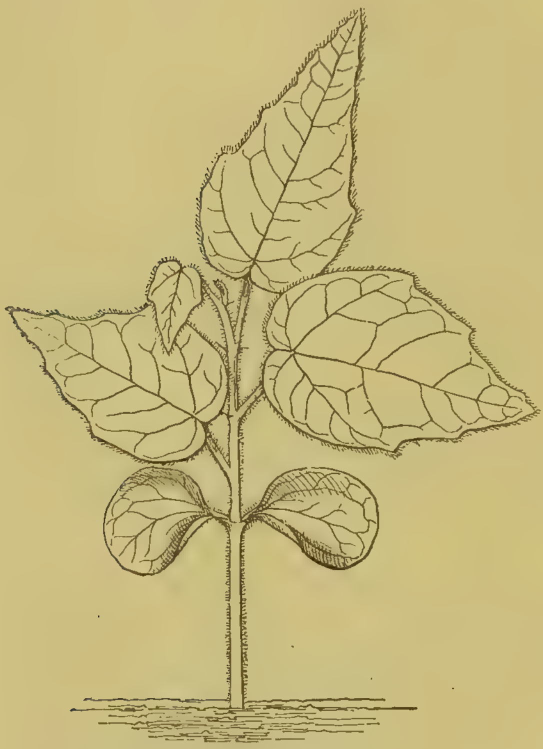

Fig. 221.—*Berrya Ammonilla*. Nat. size.

No. 1. Ovate, with a cordate base, five-nerved, and obsoletely toothed above the two large lateral obtuse teeth, into which the middle pair of strong nerves is directed.

No. 2. Similar, but broader.

No. 3. Acuminate, and (at least in the young stage) narrower than the first and second; venation the same.

Corchorus olitorius, *L.* (fig. 222).

Hypocotyl erect, terete, rather fleshy, thinly pubescent, about 8 mm. long.

Cotyledons ovate, obtuse, five-nerved at the base, rather fleshy, glabrous, petiolate; lamina 7 mm. long, 5 mm. broad; petiole thinly pubescent or glabrous, flattened above, convex beneath, 3·25 mm. long.

Stem erect, terete, thinly pubescent, pale green; 1st internode 6·5 mm. long, 2nd and 3rd each 1·5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, glabrous, plicate in vernation, alternately penninerved, a deep shining green above, paler beneath; petioles semiterete, flattened on the upper side, pubescent; stipules subulate, slender, entire, free, glabrous.

No. 1. Small, ovate, serrate, subcuneate at the base.

Nos. 2–4. Ovate, acute or subacute, round and trinerved at the base, serrate.

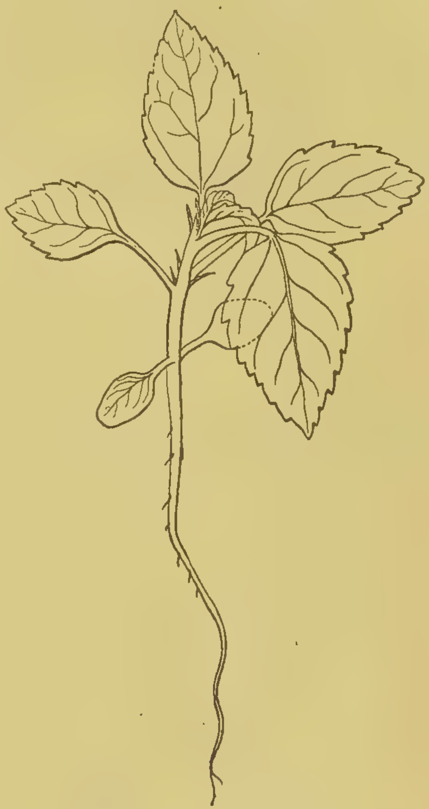

FIG. 222.—*Corchorus olitorius.* Nat. size.

Tilia vulgaris, *Hayne* (fig. 223).

Fruit an ovoid or subglobose nut, fifteen-angled, tomentose, with somewhat rufous hairs, one-celled by the rupture of the septa, one-seeded, tipped with the persistent base of the style, attached to a large deciduous bract which ensures dispersion by aid of the wind.

Seed ascending or erect, obovoid or subglobose, deep brown, smooth with a firm or crustaceous coat of two distinct layers; hilum, raphe, &c. as in T. petiolaris.

Endosperm copious, firm, fleshy, pale yellow or nearly white, surrounding the embryo, which pierces it in several places, and is almost naked at those points.

Embryo primarily straight, ultimately large, bent, divided, with its parts curved or arched: cotyledons applied face to face, originally ovate, obtuse, entire, ultimately five-lobed from an ovate or deltoid subcordate base, deflexed bodily downwards towards the ventral aspect of the radicle, then again upturned with the tips of the segments arched over to the dorsal aspect and piercing almost through the endosperm at those points. Each cotyledon has two basal subopposite nerves running into the basal segments, and two alternate ones running into the middle segments, and also a strong median nerve; segments narrowly ovate, obtuse—terminal one longest and narrowest; radicle cylindrical, obtuse, about 2·5–2·75 mm. long.

Seedling.

Hypocotyl erect, terete, pubescent or almost glabrous, pale green, or afterwards red, 2·8 to 4·5 cm. long.

Cotyledons broad, foliaceous, rhomboid and palmately five-lobed, five-nerved at the base, with the outer and lower pair of nerves slender, alternately nerved upwards, reticulate, shining and thinly pubescent on both surfaces, deep green above, paler beneath, petiolate; lobes oblong, obtuse, with a strong nerve running into each, the basal ones always largest and sometimes ovate, the middle pair of lobes always the smallest and oblong or subulate; lamina 1·5–2·1 cm. long, 1·7–2·5 cm. from tip to tip of the basal pair of lobes; petiole semi-terete, shallowly channelled above, pubescent, 6–8 mm. long.

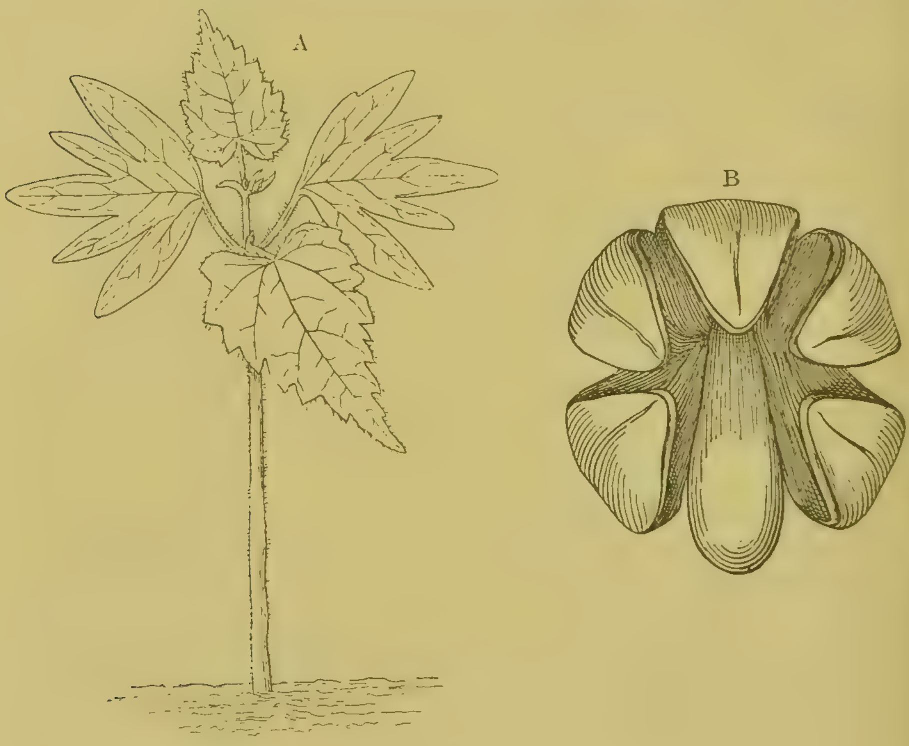

FIG. 223.—*Tilia vulgaris*. A, seedling, nat. size. B, embryo, × 8.

Stem erect, flexuous or bent at each node, densely pubescent: hairs simple or stellate, pale green, ultimately woody; 1st internode ·75–1 mm. long; second 2–5·5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, five- to seven-nerved at the base, and alternately nerved upwards, reticulate, pubescent on both surfaces in the seedling stage, becoming glabrous in the adult plant, with woolly tufts at the junction of the lateral nerves and the midrib on the under side, more or less shiny on both surfaces, deep green above, paler beneath ; stipules oblong, obtuse, seated at the union of the petiole with the stem, pale-coloured or scarious, deciduous ; petioles terete, tapering upwards from a stout base, densely pubescent with simple or stellate hairs.

No. 1. Cordate-ovate, acuminate, five- or faintly seven-nerved from the base, irregularly serrate, slightly oblique at the base or almost equal, with strong axillary buds.

No. 2. Cordate, acuminate, obtuse or subacute, more or less oblique at the base, irregularly serrate, with strong axillary buds.

Tilia petiolaris, *DC.* (fig. 224).

Fruit five-celled, one-seeded, globose, tomentose or downy and pale greenish-white, thick-walled, woody or corky internally, indehiscent.

Seed globose or subobovoid, pale white, pushing the other cells aside and monopolising the greater part of the fruit; hilum ventral somewhat above the base; raphe ventral ; chalaza apical or rather towards the dorsal aspect of the upper end of the seed, marked externally with a clear or nearly transparent space, but very prominent internally, forming a shortly conical projection with a broad base ; radicle inferior.

Endosperm in the young seed pale, transparent, and soft or fleshy, according to age.

Embryo in a very young stage straight, with a stout, obtuse, radicle and two ovate, obtuse, plano-convex, fleshy, pale green cotyledons.

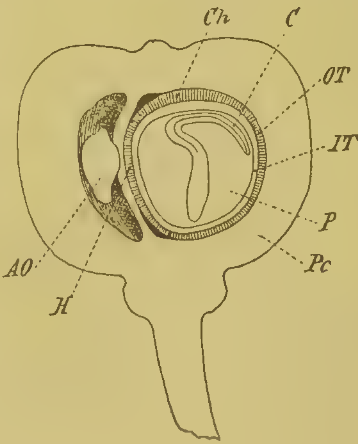

Fig. 224.—*Tilia petiolaris*, × 4. Longitudinal section of fruit: *Ch*, chalaza ; *C*, cotyledons ; *OT*, testa ; *IT*, tegmen ; *P*, endosperm ; *Pc*, pericarp ; *H*, hilum ; *AO*, aborted ovule.

Aristotelia racemosa (fig. 225).

Root long, woody, branched, with many brown fibrous lateral rootlets.

Hypocotyl woody, 1–2 cm. long, 1 mm. thick, terete, smooth, yellowish-brown.

Cotyledons shortly stalked, 5–6 mm. long, 3–4 mm. broad, broadly ovate or oblong-ovate, rounded at base and apex, entire, flat, indistinctly nerved, membranous, dull green above, paler below, glabrous.

Stem, lower part like the hypocotyl, upper somewhat succulent, downy, terete.

Leaves simple, cauline, alternate or mostly opposite or subopposite, exstipulate (?), petiolate, glabrous above, pubescent beneath, coriaceous, alternately penninerved and reticulate; stipules apparently obsolete.

Nos. 1 and 2. Opposite, shortly stalked, 1 cm. long, 4 mm. broad, ovate-lanceolate, acuminate, prominently penninerved, thin, with a few hairs on the deeply serrated margin and on the pale lower surface; upper surface glabrous and dull green.

Nos. 3–8. Alternate, larger.

Nos. 9–12. In pairs, 4–5 cm. long, 2·5 cm. broad, with long, stout, pubescent petioles, coloured like the stem; lamina cordate-ovate, acuminate or cuspidate, irregularly and very deeply serrated, with acute teeth; penninerved, with very distinct, reticulate veins, upper surface as in the first pair, lower with red midrib and nerves.

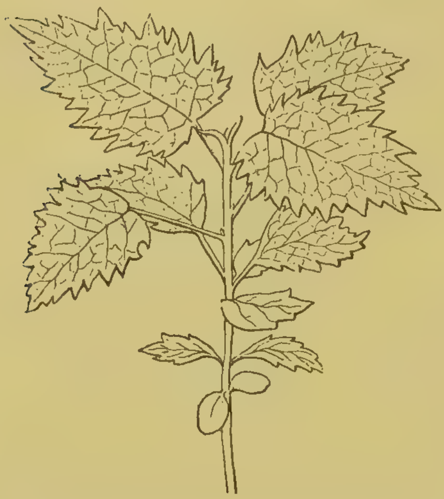

FIG. 225.—*Aristotelia racemosa.* Nat. size.

Elæocarpus oblongus, *Sm.* (fig. 226).

Hypocotyl about 8 cm. long, 4 mm. thick near the base, 2·5 mm. just beneath the cotyledons, firm, terete, glabrous, red, brownish towards the root.

Cotyledons very persistent, subsessile, nearly equal, 6 cm. long, 2·5 cm. broad, oblong or oblong-lanceolate, subacute at the base, rounded at the apex, entire, trinerved, the two lateral nerves very short in comparison with the very prominent midrib, reticulate, subcoriaceous, glabrous, light green with raised venation on the upper surface, paler, smooth, and shining below; nerves and veins red on both surfaces.

Stem firm, terete, pubescent, red, the first few internodes 5 mm. long, 2–3 mm. thick.

Leaves simple, cauline, opposite or subopposite, stipulate, shortly petiolate, ciliate, pubescent on the upper surface and on the nerves beneath when young, alternately incurvinerved and reticulate,

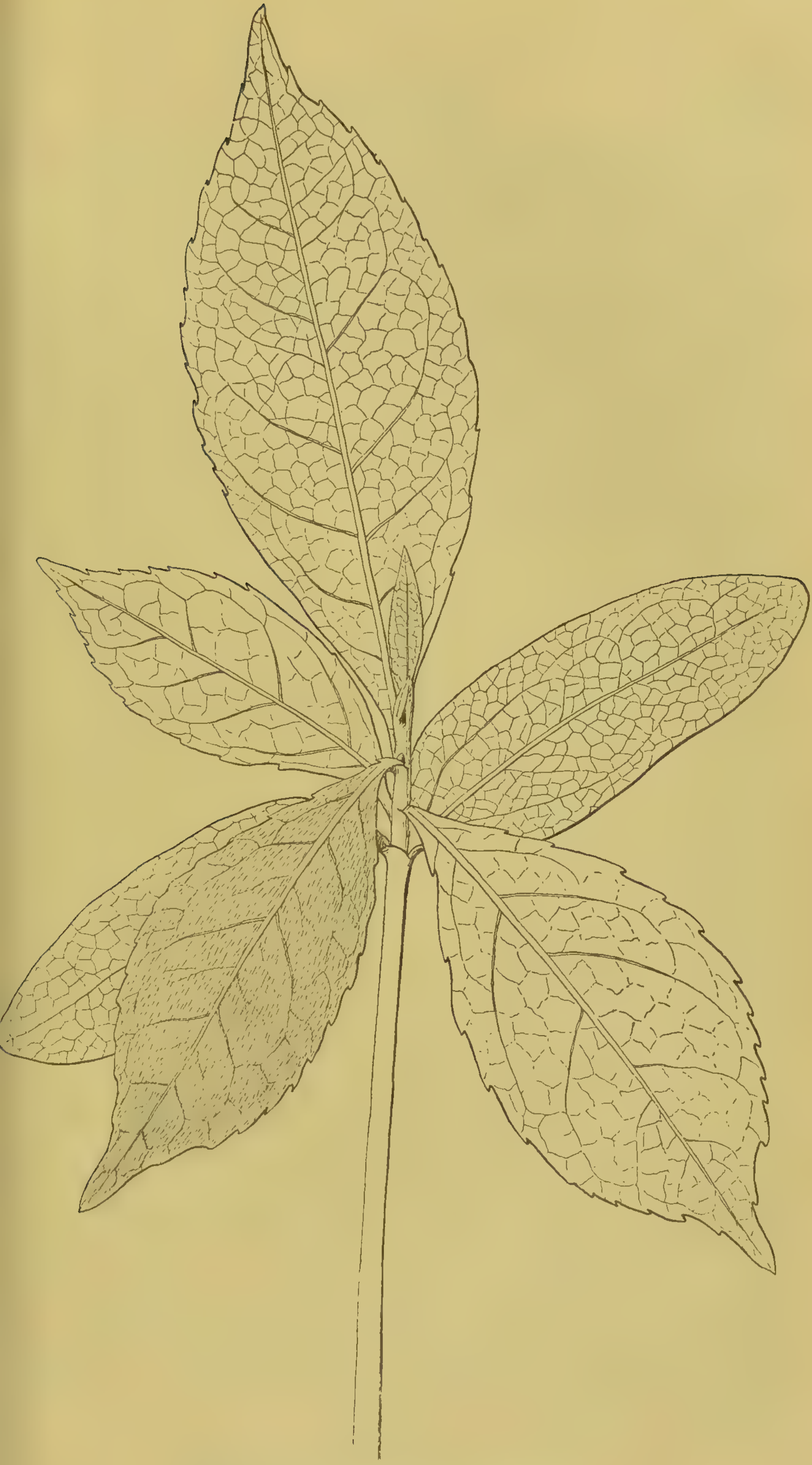

FIG. 226.—*Elæocarpus oblongus.* Nat. size.

coriaceous ; petioles very short, semiterete ; stipules very small, black, bristle-like, inconspicuous.

No. 1. A little smaller than the cotyledons, shortly stalked, elliptic-lanceolate, acuminate, shallowly serrate with adpressed apiculate teeth, and one black mucro at each side of base of the lamina ; venation incurvinerved and reticulate with the nerves and veins red on both sides, silky with adpressed hairs on the margin and upper surface, as well as on the nerves of the lower, coloured like the cotyledons, but showing the nervation and venation equally well on both sides.

Nos. 2–5. Similar, only larger and more elliptic, subacuminate.

Elæocarpus reticulatus, *Sm.*

Hypocotyl woody, erect, terete, glabrous, pale brownish, 1·8 cm. above the soil.

Cotyledons persistent, lanceolate, obtuse, opaque, coriaceous, obscurely penninerved and reticulate, glabrous ; lamina 1·9 cm. long, 7·25 mm. broad ; petiole broad, semi-amplexicaul, 1 mm. long.

Stem woody, erect, terete, pubescent, pale brown ; 1st internode 3 mm. long ; 2nd 2 mm. ; 3rd 5·25 mm. ; 4th 5·25 mm. ; 5th 7 mm. ; 6th 5 mm. ; 7th 5 mm. ; 8th 7·5 mm. ; 9th 7 mm.

Leaves alternate, serrate ; teeth incurved ; mucronate, thinly pubescent when young, ultimately coriaceous, glabrous, alternately penninerved, reticulate prominently above, but not prominently beneath, with the midrib prominent on both surfaces ; petioles very short, stout, flattened above with a prominent midrib, much thickened beneath at the very base and decurrent on the stem forming a ridge, pubescent when young, ultimately glabrous ; stipules minute, tooth-like.

No. 1. Smaller than the cotyledons, lanceolate, acute, deep green above, paler beneath, as are the others.

Nos. 2–5. Lanceolate, acuminate, mucronate.

Nos. 6–9. Lanceolate-elliptic, acuminate, obtuse, mucronate.

Ultimate leaves oblong, shortly acuminate, acute, tapered a little to both ends ; petiole rigid, channelled above, thickened at its insertion both with the lamina and the stem.

LINEÆ.

Benth. et Hook. *Gen. Pl.* i. 241.

Fruit and Seed.—The ovary is superior, syncarpous, and typically five-celled, but often becoming spuriously ten-celled by an outgrowth from the inner face of each carpel. Exceptions to the general rule occur in Radiola millegrana, where the flower is tetramerous. The ovary of Reinwardtia tetragyna is also typically four-celled, but that of R. trigyna and Anisadenia is three-celled. The ovules are geminate and collateral, rarely superposed, suspended from the inner angle of each cell near the top, and are anatropous, with the micropyle superior, and the raphe ventral. The loculi of several species of Erythroxylon and Durandea are one-ovuled.

The fruit is a capsule breaking up into as many cocci as there are carpels, and dehiscing along the ventral suture or separating along the dorsal suture, thus forming twice as many pieces as there are carpels. It is membranous, one-seeded by abortion, and said to be indehiscent in Anisadenia. The fruit of the tribes Hugonieæ and Erythroxyleæ is drupaceous or baccate, with as many pyrenes as there are carpels, or with one only by suppression and then one-seeded. The fruits of the Ixonantheæ are subdrupaceous, but ultimately dehisce at the apex. The cocci of Phyllocosmus are not septate. The seeds are solitary or geminate in each cell, pendulous, anatropous, often compressed laterally with the ventral edge and raphe to the placenta, obovoid or oblong, with the testa sometimes, though rarely, drawn out into a membranous wing. The endosperm is fleshy or cartilaginous, copious, scanty, or altogether wanting; and the embryo is straight or rarely incurved, almost equalling the cavity in length; the cotyledons are flat, plano-convex, ovate, elliptic, or linear, and foliaceous, and the superior radicle nearly equals them in length, with some exceptions such as Anisadenia and Sarcotheca, in which it is short.

The seeds are always laterally compressed when the carpels number three, four, or five with twice as many seeds, but when the carpels are reduced to one, they are thick, obovoid, and even or angled. Winged seeds are met with in Hebepetalum and some species of Ixonanthes, while those of Phyllocosmus and occasionally of Ixonanthes are furnished with a lacerated, mitriform aril. Normally the embryo is axile, that is, it lies in the centre of the endosperm, but there is an exception in Ixonanthes, where it is lateral. Hugonia and Roucheria are exceptional in their embryo being sometimes more or less incurved ; in the mature seeds of Anisadenia and Linum it is green.

Linum may be taken as a type of those with a dry capsular fruit. In the early stage of the ovary it is five-celled, with two ovules in each of slightly different ages and slightly superposed. The ovules at first are represented by small papillæ, and as the integuments are developed and they become anatropous, a false partition begins to grow towards the interior from the inner face of the carpel and separates the ovules immediately they have become anatropous. Endosperm is wanting in the mature seed, and the cotyledons of the embryo are elliptic, conforming in shape to that of the seed. The drupaceous type is represented by Hugonia Mystax. The fruit is globose, fleshy externally, with a bony endocarp, spuriously ten-celled with one or two seeds in each true cell. As it ripens the interior becomes pulpy, and the dissepiments obliterated. The laterally flattened seeds differ from those of Linum in containing endosperm. The embryo almost equals the latter in length, and is pale yellow, and slightly incurved ; the cotyledons are oblong, flat, foliaceous, thin, and alternately penninerved. The seeds of Linum when moistened emit a copious mucilage, which attaches them to the soil, and probably serves to facilitate the exit of the young plant.

Cotyledons.—Just as there is very little variation of any importance amongst the seeds, so with the cotyledons of those seedlings coming under my notice. They are broadly oval or roundly obovate, trinerved, suddenly narrowed into a very short petiole. Those of Linum perenne are oval, rather opaque, with an obscure venation, about 5·25 mm. long, including the petiole, and 3·25 mm. wide. They are longer and several times wider than the primary leaves. Those of L. campanulatum agree, except in being rather smaller, while those of L. monogynum (fig. 227) and L. Leoni are very much larger. Those of the latter are entire or inclined to be slightly emarginate, fleshy, and indistinctly trinerved.

Linum perenne, *L.*

Hypocotyl erect, terete, glabrous, white below ground and purplish-brown above it, 1·5 cm. long.

Cotyledons oval, obtuse, entire, tapering to a very short petiole, glabrous, deep green, often stained brown, about 5·25 mm. long including the petiole, 3·25 mm. wide.

Stem herbaceous, erect, terete, glabrous, minutely scabrous, pale green or brownish; internodes very short, 1st and 2nd undeveloped; 3rd 4 mm. long; 4th 1 mm. long; 5th ·75 mm.; 6th, 7th, &c., 1 mm. long.

Leaves simple, entire, radical and cauline, alternate, exstipulate, sessile, or slightly narrowed to the base, deep glaucous green, glabrous, subfleshy, one-, ultimately three-nerved, minutely scabrous at the margin, convex on the back, slightly concave above by reason of the upturned margins.

Nos. 1 and 2. Decussating with and close to the cotyledons, appearing opposite, linear-oblong, obtuse, or subacute.

Nos. 3–20. Linear-oblong, obtuse, alternate, separated by short internodes, minutely scabrous beneath, one-nerved.

Ultimate leaves on barren shoots linear, obtuse, generally minutely cuspidate, one- or obscurely three-nerved, subfleshy; on flowering shoots linear, acute, rather elongated, trinerved.

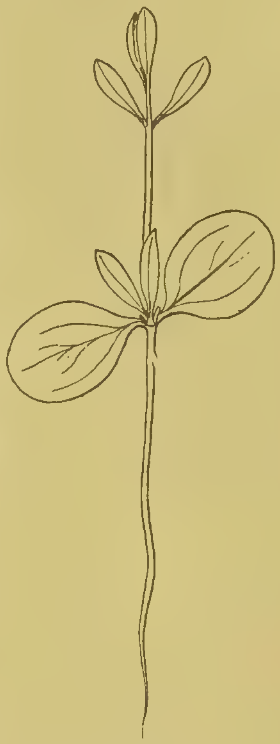

Fig. 227.
Linum monogynum.
Nat. size.

Linum monogynum, *Forst.* (fig. 227).

Primary root a long tap-root, colourless, unbranched in its early stages.

Hypocotyl as in L. perenne, about 2 cm. long, 1 mm. thick, firm.

Cotyledons subsessile, 1·5 cm. long, about 1 cm. broad, rotund-obovate, trinerved, entire, glabrous, thin, light greyish-green.

Stem like the hypocotyl; 1st internode 1 mm.; 2nd undeveloped; 3rd 2 cm.

Leaves very similar to those of L. perenne, sometimes opposite (as in the first two to three pairs), tapering to the base in the seedling stage, ultimately more strictly sessile, generally one-nerved, pale green.

Nos. 1 and 2. Only 1 mm. above the cotyledons, subsessile, 7·5 mm. long, 3 mm. broad, oblanceolate, subacute at the apex, entire, with distinct midrib, glabrous, thin, light greyish-green.

Nos. 3 and 4. Similar.

Linum campanulatum, *L.*

Hypocotyl mostly subterranean, tapering indistinguishably into the root.

Cotyledons obovate, otherwise as in L. monogynum, petiolate; lamina 7·5 mm. long, 5 mm. broad; petiole flattened or slightly grooved above, convex on the back and subscabrous, 3·5 mm. long.

Stem herbaceous, erect, terete, glabrous, brown; 1st internode 1·7 cm. long; 2nd 3 mm.; above this 1 mm. each or crowded.

Leaves tapering to the base, trinerved from base almost to apex, obscurely alternately penninerved above the middle, opaque, deep glaucous-green on both surfaces, crowded, ascending.

Nos. 1 and 2. Small, opposite, spathulate, obtuse, apiculate.

All above this obovate, obtuse, apiculate, crowded.

HUMIRIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 246.

The five-, rarely six- to seven-celled ovary contains a solitary, pendulous, anatropous ovule in each cell, or two, rarely three, in Vantanea, while Humiria has sometimes two superposed ovules. The raphe is ventral. The fruit is drupaceous with a bony endocarp, one- to three-celled and -seeded by abortion, and indehiscent. Where two seeds occur in a loculus of Humiria they are separated from one another by a spurious transverse septum. The seeds are oblong, with a membranous testa, and contain a copious, fleshy endosperm.

The embryo is straight in the axis of the endosperm, and has short, blunt cotyledons and generally an elongated, superior radicle.

The Order contains about twenty species of large or small trees, with alternate, entire or crenulate, exstipulate leaves.

MALPIGHIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 247.

Fruit and Seed.—The ovary is superior, generally consisting of three carpels, rarely two or four, more or less connate into a three-celled ovary, or apocarpous, with one ovule in each cell; the ovule is almost orthotropous or semianatropous in Hiptage Madablota, ascending from a broad pendulous funicle, and straight or curved; the raphe is on the ventral aspect, and the micropyle is superior. The mature carpels are three in number or fewer, one-seeded and coherent into a fleshy or woody drupe, distinct and separating into usually winged samaras, rarely two-valved. The seed is obliquely suspended from the inner angle of each cell, and is exalbuminous. The seed-coat is double, both coats being as a rule membranous. The embryo varies in being straight, curved, or hooked, very rarely circinate; and the cotyledons are flat, or fleshy and thick, filling the seed, and often unequal. The radicle is short, superior, and the plumule is but little developed.

The seeds may be roughly classified into six groups according to the form of the embryo, which is exceedingly variable. Those characteristics however by which the groups are distinguished are not constant, while in many cases two or three of them apply to one genus, or to different species of a genus, so that the groups frequently overlap one another. The embryo is straight in Bunchosia, Aspidopterys, Jubelina, and some species of Malpighia. More often however the cotyledons are more or less curved, as in Lasiocarpus, Verrucularia, Acridocarpus, Ryssopterys, Peixotoa, Aspicarpa, Camarea, Janusia, Schwannia, and in some species of Hiptage, while in Banisteria they may be straight, incurved, or inflexed. This forms a transition to the next group, in which the cotyledons are inflexed or uncinate about the middle or towards the apex. Some of the species of Malpighia, Tristellateia, and Tetrapterys also have their cotyledons inflexed at the apex. The species generally of Diacidia, Clonodia, Lophanthera, Ptilochæta, Triaspis, Triopterys, Hiræa, and Diplopterys have the cotyledons inflexed; while those of Janusia are fleshy and curved, but are somewhat exceptional in having the inner one uncinate at the tip. A fourth type has the cotyledons circinate, those of Byrsonima and Dinemandra being linear and semiterete. Pterandra is very exceptional in the Order in having the seed-leaves flattened and convolute, while the inner one is longer and rolled up in a spiral of many coils.

The seeds are often large, and as they contain no endosperm, the embryos in numerous cases are thick and fleshy. The gynœcium in Hiptage Madablota consists of three carpels, and is three-celled, with one ovule in each cell. The ovule is campylotropous or semi-anatropous, suspended from the middle by a broad obliquely attached funicle. The fruit is samaroid with three strong wings diverging from its upper edges, and when mature splits into three pieces. The seed is transversely and broadly oblong-reniform, large, and conforming to the seed-cavity of the samara. The embryo is large, slightly curved, thick, fleshy, pale yellow or white, and the cotyledons are unequal, plano-convex, with the smaller one uppermost, lying in the sinus of the curve; both lie in the narrow plane of the seed, with their edges to the ventral suture of the carpel. The radicle is superior, and so short as to be hardly noticeable, just serving to unite the cotyledons. Other genera agreeing with Hiptage in having fleshy seed-leaves are Acmanthera, Acridocarpus, Brachypterys, Stigmaphyllon, Tetrapterys, and Hiræa.

Hiptage Madablota may be again referred to as a type having unequal cotyledons. Others agreeing with it in this respect are Burdachia, Dicella, Thryallis, Galphimia, Heteropterys, Stigmaphyllon, Tetrapterys, and Pterandra. This inequality is sometimes carried so far that one of the cotyledons becomes quite minute, as in Hiræa. The embryo of Brachypterys appears undivided, but one cotyledon becomes aborted, and the other thick, and hooked at the apex. According to Grisebach[1] this is what takes place in Glandonia, a genus containing a single species from northern Brazil. According to other authorities[2] the cotyledons have become amalgamated or conferruminate. These three cases may be considered exceptional in the Order or abnormal, and the gradual outcome of the curved or twisted condition of the ovary, which is neither strictly anatropous nor orthotropous, but partly both. The outer cotyledon becomes the larger, and folded round the inner one to a greater or less extent, and the latter therefore becomes gradually smaller and finally more or less aborted, as in Abronia belonging to the Nyctagineæ. Other curious cases occur in several species of Banisteria, Heteropterys, and Stigmaphyllon.

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[1] Griseb. in *Mart. Fl. Bras. Malpigh.* p. 23.

[2] *Gen. Plant.* i. 252.

The seeds of Stigmaphyllon are also remarkable in containing two or three embryos.

Hiptage Madablota, *Gaertn.*

Fruit separating when mature into three samaras, each one-celled, one-seeded, and furnished at the upper edges with three strong diverging wings and an apical much smaller one; walls of ovary dry, coriaceous to woody, and tough.

Seed transversely and broadly oblong-reniform, comparatively large, conforming to the interior of the samara, suspended at or near its centre by a broad funicle, which arises from the ventral side of the samara, below the middle of the cell, and is obliquely and slightly attached to the testa; raphe short, broad at the upper edge of the ventral aspect of the seed; micropyle superior, contiguous to the hilum; chalaza on the opposite side of the hilum from the micropyle; testa and tegmen both thin and membranous, pale brown.

Endosperm absent.

Embryo large and conforming to the interior of the seed, which it closely fills, slightly curved, fleshy, pale yellowish or white; cotyledons unequal, curved, plano-convex, fleshy, filling the seed, obtuse, entire, with the smaller one uppermost and in the inner angle of the curve, both lying in the narrower plane of the seed, which is deeper than wide, so that both the cotyledons go to make up the depth of the seed, and have their edges to the ventral suture of the carpel; radicle extremely short, superior, hardly prominent.

ZYGOPHYLLEÆ.

Benth. et Hook. *Gen. Pl.* i. 262.

Fruit and Seed.—The ovary of the Zygophylleæ is four- or five-, rarely two- to twelve-celled, and the ovules vary from two to many in each cell. They are pendulous and anatropous or sometimes ascending with a ventral raphe, have a superior micropyle, and are often filiform. A remarkable exception occurs in a few species of Tribulus, where the carpels opposite the petals are transversely three- to five-locellate, both in the young and the mature state, so that the seeds lie in an ascending direction one above the other with partitions between them.

The fruit is very variable in the Order, coriaceous or crustaceous, dividing into dehiscent or indehiscent cocci, which are connate, or separate from the placental axis; at other times it is a capsule dehiscing loculicidally, and in a few the endocarp is horny. The fruit of Nitraria is drupaceous when mature, one-celled and one-seeded although two- to six-celled in the young state. The seeds are pendulous, and solitary in most cases, oblong or linear, with a membranous, crustaceous, or thick and slimy testa. They contain a thin layer of endosperm, often fleshy or horny, and are rarely exalbuminous.

The embryo is straight or nearly so, green, and equalling the endosperm in length. The cotyledons are foliaceous and oblong or linear, the radicle rather short.

GERANIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 269.

Fruit and Seed.—The gynœcium of the Geraniaceæ is superior and syncarpous, consisting of three to five, rarely two carpels. The ovary is three- to five-lobed, three- to five-celled, and in the tribes Geranieæ and Pelargonieæ the carpels are in most cases prolonged above into a long beak, attached to the central axis, which is also greatly prolonged between and beyond the seed-bearing portion: in the other tribes the beak is usually absent. The ovules are geminate and contiguously superposed, or solitary and pendulous, with the micropyle superior and the raphe ventral, or transverse with the raphe lateral. Where the thalamus is flat, as in Limnanthes, the ovule is solitary and ascending with the micropyle inferior. The ovules vary from two to many in the tribes Wendtieæ and Oxalideæ, are horizontal or pendulous, and arranged in a single or double series along the placenta. The fruit is a schizocarp in many cases, three- to five-lobed, and breaking away from the axis in as many one-seeded pieces, the beak of which becomes revolute carrying the seed upwards with it. In other cases, such as that of Limnantheæ and Tropæolum, the fruit breaks up into three to five indehiscent, hardened cocci. The two- to many-seeded fruits are capsular, dehiscing loculicidally with persistent valves, as in Oxalis, or the valves break away with elasticity from the placentas, as in Impatiens. In a few cases the fruit is baccate, many-seeded, and indehiscent, as in Averrhoa.

The seeds are pendulous, horizontal, or ascending, the first and last being characteristic of one- or few-seeded fruits. The testa is thin, rarely somewhat crustaceous. Endosperm is absent or rarely present in some quantity and fleshy. The embryo is curved or straight, often green, and the cotyledons are foliaceous and variously convolute longitudinally or twisted, flat, plaited, or plano-convex, or they are thick and fleshy as in Tropæolum. The radicle is short in straight embryos, and pointing to the hilum, or, as in the Geranieæ and Pelargonieæ, is long and incumbent upon the back of the cotyledon next to the raphe, and, together with the tips of the cotyledons, points to the base of the fruit. The whole Order may be roughly divided into five groups according to the form of the embryo and the presence or absence of endosperm. On the amount of the latter present in the seed depends to a large extent the size, form, and modification of the embryo. The larger the quantity present, the smaller and simpler the embryo. The groups may be characterised as follows:—(1) endosperm present, embryo straight; (2) endosperm present, embryo curved; (3) endosperm present, cotyledons plicate; (4) endosperm absent, embryo fleshy, straight; (5) endosperm absent or rarely present in small quantity, cotyledons convolute or induplicate-plicate. These characters do not in all cases indicate the genera which are regarded as most closely allied, but they are all well marked in the seeds, and the members of different tribes do not much overlap one another.

To the first group belong Rhynchotheca, Oxalis, Averrhoa, and perhaps Dapania. The seed of Rhynchotheca contains a small quantity of endosperm, a straight embryo, flat cotyledons, and belongs to the tribe Wendtieæ; Wendtia itself does not seem to have been described, and I have had no opportunity of examining it. The others belong to the tribe Oxalideæ. Oxalis has a capsular, loculicidally dehiscent, five-celled fruit with one or many seeds in each cell. The outer integument of the seed is fleshy and breaks away elastically in the form of an aril, while the testa is crustaceous. The endosperm is fleshy, and the small embryo straight with broadly ovate cotyledons. The fruit of Averrhoa is baccate and indehiscent, containing numerous naked or arillate seeds, with a small quantity of fleshy endosperm, and a straight embryo. The fruit of Dapania is fleshy and five-lobed, and the seed it contains is covered by a lacerated, somewhat two-lipped aril, and has a fleshy endosperm. The embryo is slightly curved, leading to the next group; and the oval cotyledons are cordate at the base.

2. The curved embryo is represented by Biebersteinia and Viviania, belonging to distinct tribes (Geranieæ and Vivianeæ respectively). The seed of the former is curved and contains a thin, fleshy, somewhat one-sided layer of endosperm. The arched or bent embryo has rather thickened cotyledons, a scarcely shorter, superior radicle, and conforms in outline to that of the seed. Viviania has closely superposed geminate ovules in each cell, and when both mature into seeds, the one is ascending and the other descending, and they contain a fleshy endosperm. The embryo is narrow, linear, and strongly curved or circinate.

3. The third type, represented by Balbisia, also contains a thin fleshy layer of endosperm in its seeds, which are small, many-angled by mutual compression, and arranged in a double series. Its chief distinction consists in the cotyledons being plicate and in the radicle being laid over the back of them or enclosed in their folds.

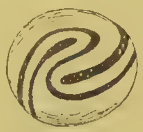
4. Endosperm is wanting and the embryo straight and fleshy in Tropæolum, Limnanthes, Flœrkea, Impatiens, and Hydrocera, belonging to three different tribes, which some authors consider distinct Orders. The ovary of Tropæolum is trilobed, three-celled, and contains a single pendulous ovule in each cell, with a superior micropyle. The fruit is at first fleshy, but when mature becomes a schizocarp, breaking up into three indehiscent cocci, which fall away from the short persistent axis, and have hardened, rugose walls, ultimately becoming dry and cortical. The seed is exalbuminous, and the straight embryo consists of two thick and fleshy closely applied or almost conferruminate cotyledons, which, together with the extremely short radicle, completely fill the cavity of the seed, which again fills the carpel.

When the embryo is still very young, the cotyledons are oval or transversely oblong, entire, deep green, and diverging widely. Later on they become broadly cordate, and deeply concave on the inner faces. At a further stage they become fleshy, and form more or less completely a sphere, while the notch at the base becomes deeper until distinct auricles are produced. Finally they become closely applied to one another but separable, while the basal auricles become quite close, embedding the radicle, and leaving only its extreme tip exposed. At the same time they lose their green colour, and, being globose, completely fill the seed. The fruit, seed, and embryo of Flœrkea conform very closely in structure to those of Tropæolum, while Limnanthes differs in having five carpels. The fruit of neither is fleshy, and the receptacle or thalamus is nearly flat, while the carpels are beakless. The cotyledons are thick, fleshy, and cordate at the base, enclosing the very short radicle. The fruit of Impatiens is a five-celled capsule, the valves of which on maturity spring elastically from the placentas, from the base upwards, and roll backwards or downwards from the top inwards. The seeds of I. parviflora (fig. 233) are pendulous, anatropous, obovoid, and marked longitudinally with lines of minute protuberances. The chalaza is apical, forming a small thickened knob externally to the testa, which is here slightly indented. The embryo is straight, and the cotyledons obovate-oblong, fleshy, plano-convex, subcordate at the base, partly surrounding the radicle, and minutely emarginate, apparently owing to the indentation of the testa at the thickened chalaza. In I. chinensis there is sometimes a slight depression at the chalaza, which occasionally is quite marked. The seeds of I. Roylei are pyriform with a small depression at the broad apical end, and rough with small points. The embryo is similar to that of I. parviflora, and the cotyledons are broadly obovate with the apical notch well marked.

5. The fifth group, in which endosperm is absent, and the cotyledons convolute or induplicate-plicate, is represented by Geranium, Erodium, Monsonia, and Sarcocaulon, of the tribe Geranieæ, and Pelargonium of the Pelargonieæ. The various species of Geranium have the most complicated embryo of the three better known genera, and constitute the best type of the group. The ovary consists of five carpels, is deeply five-lobed, five-celled, and ten-ovuled. The axis is greatly prolonged between the carpels, and each of the latter is produced into a long beak attached to the axis, except near the top where they separate into five branches, which are stigmatose along their inner face. The geminate ovules are slightly superposed, incurved, and semianatropous. The hilum is ventral, and above the middle of the seed, and the micropyle is on the upper side of this. One of the two ovules only becomes fertilised, and in a number of specimens examined it has always been the upper one. The seed is oblong or subcylindrical, finely tuberculated, about equally thick at both ends, and fixed to the placenta a little above its middle. The chalaza is at the lower end close to the base of the carpel. Endosperm is absent, and the curved embryo, which is green, at least while fresh, occupies the whole of the seed.

Taking G. Wallichianum as a type, we find that the radicle is the only part that is curved; and assuming that the embryo starts from near the micropyle above the middle of the seed, then it would grow until it reached the upper end, when the apex curves downwards until it reaches the base, and here we always find the apex of the cotyledons pointing to the base of the carpels or ovary. There still being room for the cotyledons to develop laterally, they commence to coil longitudinally round the sides of the seed in the direction of the sun when the seed is held in its natural position.

The result is that one longitudinal half of each cotyledon grows faster than the other, and grows over, enclosing the smaller half of the other, so that when the embryo is fully grown, a transverse section shows each of the cotyledons coiled in the shape of the letter S, but the small coil of each is inserted in the large coil of the other, thus—



The coils are, however, closely drawn together so as to fill the seed compactly, and the radicle is incumbent on the back of the cotyledons, but on the ventral face of the seed ; there is a small notch or cavity in the centre of the bundle or coil at its lower end into which the rather prominent chalaza fits. When flattened out the cotyledons are transversely oblong or reniform, slightly sinuate at the apex, with the midrib excurrent, forming a small tooth, and five nerves radiating from the base of the lamina and becoming slightly incurved. The base is deeply cordate, and the deep green radicle on the ventral aspect points towards the base of the ovary. The two halves of the cotyledons are unequal, the smaller one occupying the interior of the coil. The cotyledons are even already petiolate, and examination shows that this is necessary in order to allow of their becoming convolute. The inner or upper faces of the cotyledons are always applied to one another, but the coils or smaller enfolded half of each prevents the two midribs from coming in contact as they would do if the cotyledons were flat. Hence the necessity for petioles while yet in the seed. Other species agreeing with G. Wallichianum in the form of the embryo are G. pratense, G. sylvaticum, G. sanguineum, and G. bohemicum. It is more than probable that none of the species differ very widely from the type. There seems to be, however, a variation in the insertion of the ovule, for whereas G. Wallichianum has the hilum on the ventral face a little above the middle, according to a figure of Le Maout and Decaisne[1] a species of Geranium has the hilum close to the base. G. Endresii has the ovule attached as near as possible at the middle, and the radicle is of moderate length. In G. Wallichianum, the ovule being attached above the middle and campylotropous, the radicle is very short. In Le Maout and Decaisne's figure above-mentioned the ovule is practically erect and anatropous, while the radicle elongates until it almost equals the cotyledons in length.

In Erodium there is the same variation in the attachment of the seed. It is pendulous and attached above the middle in E. trichomanefolium, which is half anatropous, with the radicle and the apex of the cotyledons uppermost, while that of E. Manescavi is attached almost by the base, while the radicle is greatly elongated and reaches to the hilum, the seed being erect and almost anatropous with the micropyle inferior. The seed of E. Manescavi tapers downwards, whereas that of E. trichomanefolium tapers upwards. The wider end always includes the radicle, which in this genus is greatly thickened. There is a corresponding reduction in the width of the cotyledons, which taper somewhat towards the apex and are much less perfectly convolute than in Geranium. In E. trichomanefolium the two cotyledons are folded separately with their edges towards one another, or they slightly overlap with the thick radicle squeezed in the hollow between them. While yet in the seed there is a moderately deep notch on the margin, but below the middle on each side of both cotyledons, or the longer side only may be so notched.

The cotyledons are petiolate while yet in the seed for the same reason as in Geranium. In Erodium Manescavi one cotyledon folds over and almost completely encloses the other, which is accordingly somewhat smaller, while the much thickened radicle is flattened against the back of the outer and larger one. The embryo of E. gruinum is nearly as convoluted as that of Geranium ; but both cotyledons are somewhat foreshortened on the edges next the radicle, which is thick, fleshy, subtrigonous, and occupies a considerable amount of space.

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[1] Le Maout and Decaisne, Eng. edit. 1876, pp. 306–7.

The ovule and seed correspond to those of E. Manescavi. The cotyledons of E. moschatum are convolute, plicate, and pinnatifidly lobed.[1] The ovules of Pelargonium australe are geminate in each cell, suspended from the inner angle and anatropous, with the micropyle considerably above the middle on the ventral face. The seed is broader at the end farthest from the hilum as in the case of Erodium, a circumstance due to the radicle being thickest at that point and to the fact that the cotyledons taper to the apex like those of Erodium. The cotyledons are convolute longitudinally with one folded over the other. Both are shaped like the letter L at the apex, but only the outer one towards the base, the inner being hooked or crumpled inside the angle of the outer. They taper to the apex, which is minutely emarginate beneath the thickened portion of the chalaza; the margin is crenate, and they are shortly petiolate for the same reason as Pelargonium and Erodium. The radicle is incumbent on the cotyledons on the ventral aspect, where the testa is bulged out to accommodate it, the inflated portion tapering to a point above the middle.

Cotyledons.—About half a dozen distinct types of cotyledons may be noted, and modifications are frequent in that represented by Erodium and Pelargonium. The simplest are those occurring in exalbuminous seeds, and especially where the embryo is straight and has its cotyledons simply thickened so as to fill the seed. The least complex of the types observed is represented by Oxalis corniculata (fig. 232). The cotyledons are small, oblong-ovate, very obtuse, shortly petiolate, glabrous, and have a very indistinct venation. Those of O. sensitiva are sessile, and slightly pubescent at the margin, but otherwise similar to the above. Some species have broadly oblong, slightly emarginate, trinerved, petiolate cotyledons, dependent probably on the robustness of their growth and the enlargement of all parts.

The seeds of Impatiens all seem to be modelled upon the same plan; they are pendulous and anatropous, with the radicle superior and the cotyledons always occupying the lower broader end of the seed. Hence the cotyledons vary in breadth and the shape of their apex according to the corresponding variations of the seed. The general outline is obovate or roundly obovate and emarginate, tapering gradually or suddenly into the moderately long petiole. Those of I. fruticosa (fig. 235) are broadly, almost roundly, obovate, glabrous with hairy petioles, ciliate at the margin, and obscurely trinerved with the lateral nerves incurved so as to join the middle one in the notch. This notch, as has already been observed, is due, at least partly, to the thickening of the chalaza and the indentation of the testa at that part. There can be little doubt, however, that it deepens by a subsequent more rapid development of the parts on each side of the apex, where the three principal nerves end in the water-gland. A small or minute tooth is also observable in the notch. The cotyledons of I. Balsamina (fig. 234) are also obovate, with a tendency to be broadly ovate or oval, emarginate, slightly narrowed towards the apex at times, more or less cuneate at the base, and glabrous. They are three- or faintly five-nerved. Five slender or indistinct nerves also occur in a species with lilac flowers, and the lateral ones join the midrib in the rather prominent notch. The lamina is obovate-orbicular, and appears sessile from the fact that the petioles are erect and closely applied to the stem throughout their length. The cotyledons of I. tenella are very broadly obovate, emarginate, and trinerved, while those of I. tricornis appear to be somewhat anomalous in being obliquely emarginate or shallowly and obtusely trilobed at the apex and indistinctly one- to two-nerved.

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[1] Gaertner, *De Fructibus et Seminibus*, i. 383, and t. 79, fig. 5.

A third and somewhat more complicated type occurs in Limnanthes Douglasii (fig. 230), which evidently bears considerable affinity with Tropæolum, the type of the next group. The cotyledons are roundly cordate, nearly always minutely emarginate, and marked at the apex with a small black scar, tipped with white, rather succulent, glabrous, convex above, and striated with numerous broad, shallow, ridge-like veins curving off laterally from the midrib. The petioles are rather deeply inserted in the basal notch of the lamina, and are broad at the base, sheathing the plumule. The hypocotyl is stout and subterranean, so that here again there is a necessity for petioles, which when full grown are about 1·2 cm. long. Geranium Wallichianum (fig. 228), G. polyanthus and Pelargonium australe (fig. 229) afford other good instances in this Order, and Delphinium elatum, already mentioned in Ranunculaceæ, is also a case where petioles are required to carry up the laminæ of the cotyledons to the light.

A fourth type is represented by Tropæolum majus (fig. 231). Here the cotyledons are subterranean even after germination, large, fleshy, filling the testa, and shortly petiolate, so as to facilitate the exit of the plumule.

The seed then lies on one side of the seedling, and the hypocotyl is undeveloped as in the case of other seedlings with subterranean cotyledons. In this respect T. aduncum, T. minus, and other species agree with the type just given.

The fifth type is represented by Erodium and Pelargonium, which have broadly ovate-oblong or suborbicular cotyledons, generally distinctly narrowed towards the apex. This type varies exceedingly however in different species, from cotyledons of nearly equal or symmetrical form to others that are strongly asymmetrical, while in a third modification they are lobed or pinnatifid. The least complicated type may be represented by Pelargonium bipinnatifidum, which has broadly oblong or oval, finely pubescent cotyledons, rounded or faintly emarginate at the apex, and cordate at the base, but otherwise entire, with rather long slender petioles, and a symmetrical lamina. P. humifusum agrees with the last, while P. vitifolium has suborbicular but otherwise similar cotyledons. A more generally typical form occurs in Erodium verbenæfolium, in which the cotyledons are broadly ovate-oblong, emarginate, unequally cordate at the base, where they are five-nerved, penninerved upwards, unsymmetrical, glandular, ciliate, and glandular-pubescent beneath. The auricle on one side is about 1 mm. longer than the other, a circumstance due to its being on the outside of the coil of the seed, where it has more room to develop. The channelled petioles are also of unequal length, in the proportion of 8·75 to 5·25 mm. E. gruinum and E. malacoides have altogether larger cotyledons, more deeply emarginate and more asymmetrical, but otherwise similar to the last. Lobed cotyledons are represented by Erodium trichomanefolium. Here they are oblong, incipiently emarginate, cordate at the base, asymmetrical, entire at the sides, or with a deep incision on one or both sides at or below the middle, usually very unequal at the base, fleshy, glandular-pubescent above and on the petioles. E. moschatum agrees with this, and E. cicutarium merely differs in being perhaps more deeply lobed with one or two incisions on each side. E. Manescavi merely differs in being very shallowly crenate along the sides. Pelargonium australe (fig. 229) is comparable to the last in being shallowly crenate at the sides, but is sub-lobate at the base. The fission, toothing, or lobing seems to be intended to facilitate folding in the seed. It will be noticed that the fission is always most pronounced towards the base where the cotyledons are broadest, and that the lobes are directed towards the narrower apex, so that by this means the greater width at the base is reduced. One large lobe or deep incision would accomplish in this respect what a number of smaller ones would, so that both types answer the same purpose.

The sixth type is represented by Geranium, the difference between which and Erodium has perhaps reference to the fact that while the seeds of Erodium are arranged so as to be self-sowing, and terminate in a sharp point, which more readily pierces the ground, this is not the case in Geranium, the seeds of which are rounded at both ends. The different species, as far as my observations go, agree in the relatively large size of the cotyledons, and the amount of folding which they undergo in the seed. They differ chiefly in size and vigour, and in the relative length of the hypocotyl and the petioles of the cotyledons. G. Wallichianum (fig. 228) may be taken as a representative of seedlings with a short hypocotyl and long petioles. The cotyledons are obliquely reniform, asymmetrical, deeply cordate at the base, shallowly sinuate at the apex, with the midrib excurrent, forming a small tooth, five-nerved, thinly pubescent above, ciliate at the margin, equalling one another in size, but the two halves of each unequal. The average length of the longer half of five cotyledons is 12·8 mm. and the width 8·6 mm.; on the contrary the average length of the shorter half is 11·5 mm. and the width

8·15 mm. The petioles are long, terete, or slightly flattened on the upper surface near the base, and mostly equal in length. In the short hypocotyl and long petioles, G. polyanthus agrees with G. Wallichianum, whereas G. bohemicum and G. sanguineum are types with elongated hypocotyls and short petioles, while in G. amphuloideum both hypocotyl and petioles are elongated. All the above-mentioned however agree in general characters including asymmetry. Others agreeing with the above are G. Traversii, G. pratense, and G. tuberosum.[1]

The cotyledons are all broader than long, a circumstance due to the manner of folding in the seed. The larger auricle is on the outside of the coil, and has consequently more room to develop. The apical sinus is due in part at least to a thickening of the chalaza, against which it abuts. Petioles are necessary to admit of the folds of the smaller half of each cotyledon being accommodated inside the coiled embryo, and after germination to carry the cotyledons up to the light, especially if the hypocotyl is but little developed.

Geranium Wallichianum, *Sweet* (fig. 228).

Primary root stout, fleshy, colourless, tapering, furnished with fleshy flexuose lateral rootlets.

Hypocotyl erect, terete, stout, fleshy, hairy or downy, pale towards the base and reddish upwards, partly or quite subterranean, about 5·5 mm. long.

Cotyledons obliquely reniform, deeply cordate at the base, shallowly sinuate at the apex with the midrib excurrent in the form of a small tooth, unequal-sided, five-nerved (the three inner nerves the strongest), thinly pubescent above, glabrous beneath, densely ciliate at the margin, light opaque green, obscurely reticulate; lamina 1·4 cm. long, 1·9 cm. wide, about equal, but the two halves of each cotyledon are unequal.

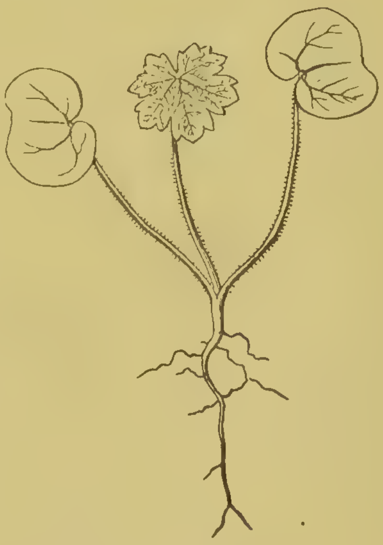

FIG. 228.
Geranium Wallichianum.
Nat. size.

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[1] See Irmisch, *Bot. Zeitung*, 1874, p. 545.

Average length of five longer halves 12·8 mm.
,, width ,, ,, ,, 8·6 mm.
,, length ,, smaller ,, 11·5 mm.
,, width ,, ,, ,, 8·15 mm. ;

petioles long, terete, hairy, the dilated base slightly flattened on the upper side, perfoliate, mostly equal in length.

Stem herbaceous, developed when about to flower, procumbent.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, palmatinerved, eight-lobed, and reticulate, hairy all over ; stipules ovate, membranous, seated on the base of the petiole or attached for half its length, but in adult specimens attached to and surrounding the node of the stem.

No. 1. Palmately seven-nerved and -lobed, reticulate ; lobes cuneate—terminal one deeply tridentate or trifid ; lateral lobes generally tridentate ; teeth obtuse, mucronate.

The cotyledons of G. sanguineum differ from the present ones only in their smaller size.

Geranium sanguineum, *L.*

There are two ovules, of which only one, usually the upper, is fertilised. The hilum is on the ventral face of the ovule a little below the middle. The raphe is also ventral and proceeds from the hilum to the base of the seed, where it terminates in the chalaza. The micropyle is close to the hilum on its upper side. The embryo originates about the middle of the ventral face of the seed with its radicle embedded in a separate cavity or tube ending in the micropyle. It grows to the upper end of the seed, and, curving round the apex, commences to grow downwards till the cotyledons rest with their apex against the chalaza. The cotyledons commence to fold by the time they reach the upper end and while there is yet plenty of room in the young seed, which is occupied by a copious, pulpy, and watery endosperm. The embryo is bright green or yellowish-green in the very early stages.

G. pratense conforms very closely to G. sanguineum.

The seedling of this species closely resembles that of G. Wallichianum.

Erodium moschatum, *L'Herit.*

There are two ovules in each loculus of the ovary ; they are slightly superimposed, and the upper one seems in all or most cases to be that which is fertilised and reaches maturity.

The carpels are oblanceolate with two oblique, glandular, depressed spots at the apex, and covered with a dense array of brownish-yellow or fuscous hairs pointing upwards.

The ovule is attached to the axile placenta near the base of the cavity of each loculus; the hilum is ventral and very close to the base of the seed; the raphe proceeds from the hilum to the base of the seed on the ventral face, terminating in the chalaza there, so that it is very short.

The radicle of the embryo is embedded in tissue or a tube close to the micropyle immediately above the hilum. The embryo grows to the upper end of the seed as in Geranium, and then bends towards the base. The curvature takes place in the radicle or rather the short hypocotyl. The cotyledons are shortly petiolate to permit of folding. They are deeply concave only on the inner face, not rolled round one another as in Geranium. This is due to the narrowness of the fruit and seed. The thickest part of the seed, that is the uppermost, is occupied by the bent part of the hypocotyl, the petioles, and base of the cotyledons. The latter are deeply concave on the inner face, and fit into one another edgeways; they are also pinnatifid with the lobes more or less imbricated and pointing towards the apex. They are nearly, although not quite, of equal width throughout after germination; but while yet in the seed the fission admits of their being folded into narrower space. This is necessary on account of the seed being very narrow and pointed like the fruit; whereas in Geranium the lower end of the fruit and seed is equally as wide as the upper end.

Erodium trichomanefolium, *L'Herit.*

Hypocotyl erect, terete, or somewhat decumbent at the base owing to the horizontal position of the seed from which it emerged, and which persists around the base of the seedling after it has attained some size, stout or somewhat succulent, glandular-pubescent, 5–9 mm. long.

Stem herbaceous or suffruticose, very short.

Cotyledons cordate or oblong-cordate, obtuse, entire at the apex or incipiently emarginate, entire at the sides or with a deep incision on one or both sides about the middle or lower down, usually very unequal at the base, thick, fleshy, glandular-pubescent above and on the petioles, glabrous beneath; lamina, 7–10·5 mm. long, 5–6 mm. wide; petiole subterete, slightly grooved above, glandular-pubescent, 1·2–1·35 cm. long.

Leaves simple, radical and cauline, alternate, stipulate (1st leaf almost or quite exstipulate and stipules usually very small in the 2nd leaf), petiolate, much divided, glaucous-green or somewhat cinereous, glandular-hairy all over; petioles subterete, channelled above, dilated and amplexicaul at the base, glandular-pubescent; stipules mostly adnate to the petioles, with membranous, colourless free tips.

No. 1. Ovate-cordate in outline, pinnatifid, with two to three oblong slightly toothed segments on each side.

Nos. 2 and 3. Cordate in outline, deeply bipinnatifid; basal pair of primary segments unequally ovate, the others oblong; secondary segments oblong or lanceolate, obtuse.

Ultimate leaves cordate-ovate, obtuse, interruptedly bipinnatisect; primary and basal pair of segments unequally or half ovate, the others subelliptic in outline, interrupted with small, irregular-sized, entire or cut segments between; secondary segments somewhat similar, smaller; tertiary segments small, subulate or lanceolate, obtuse or subacute, mucronate.

Erodium verbenæfolium, *Del.*

Hypocotyl erect, terete, glandular-pubescent, pale green, 3–5 mm. long.

Cotyledons ovate-oblong, emarginate, unequally cordate at the base, where they are five-nerved, and alternately penninerved upwards, glabrous above except towards the base, glandular-ciliate, and glandular-pubescent beneath, light green; lamina 9 mm. long on one side and 8 mm. on the other, 7·5 mm. broad; petiole channelled above, dilated at the base and amplexicaul or perfoliate, glandular-pubescent and hairy, very unequal in length, one being sometimes twice as long as the other.

Average length of two long ones 8·75 mm.
" " short " 5·25 mm.

Stem herbaceous, annual, developed when about to flower.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, glandular-pubescent on both surfaces, greyish; petioles semiterete, shallowly grooved above, dilated at the base and amplexicaul, glandular-pubescent and hairy; stipules adnate to the petiole, with rounded, hyaline, or membranous, glandular-ciliate, free points.

No. 1. Ovate-oblong, cordate at the base, bifid at the apex, deeply pinnatifid, alternately or suboppositely penninerved with the nerves directed straight into the lobes; segments obtusely dentate.

No. 2. Similar but emarginate with a tooth in the notch or tridentate at the apex.

Pelargonium australe, *Willd.* (fig. 229).

Primary root normal, tapering, fibrous, annual.

Hypocotyl erect, terete, glandular-pubescent or -hairy, pale green or suffused with red, 6–8 mm. above the soil.

Cotyledons ovate-oblong, emarginate, minutely mucronate in the notch, unequally subcordate at the base, shallowly crenate at the sides, glandular-hairy all over, light green; lamina 9–15 mm. long, 7·5–10·5 mm. broad; petiole subterete, shallowly grooved above, glandular-hairy, 1·5–2·1 cm. long.

Stem herbaceous, annual, developed when about to flower.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, light green, glandular-hairy all over, alternately and ascendingly penninerved; stipules adnate to the petiole for more than half their length, with membranous, free, whitish, glandular-ciliate, tooth-like tips; petioles semiterete, channelled above, glandular-hairy and villous, pale green.

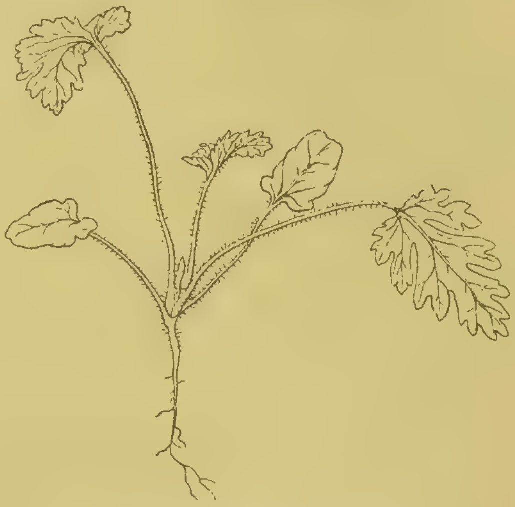

FIG. 229.—*Pelargonium australe.* Half nat. size.

Nos. 1 and 2. Ovate, obtuse, cordate at the base, pinnatifid; segments again alternately penninerved, coarsely and obtusely-toothed or the lower sublobulate.

Pelargonium bipinnatifidum, *L'Herit.*

Primary root fibrous, well developed.

Hypocotyl herbaceous, 1 cm. long, 2 mm. thick, pubescent, reddish-green.

Cotyledons oval or obovate; lamina 1·25–1·5 cm. long, 1·25 cm. broad, cordate at the base, slightly emarginate at the apex, otherwise entire, with obscure midrib, succulent, pubescent, bright green above, paler and reddish beneath; petiole pubescent and shallowly channelled, 1 cm. long, 1 mm. thick.

Stem undeveloped in the early stage of the plant.

Leaves alternate, or more often opposite, three- to five-nerved at the base and alternately nerved upwards, reticulate, pubescent, membranous; petioles generally long, tapering upwards.

No. 1. Long-stalked, cordate-ovate, obtusely serrate, lower half with palmate nerves, upper pinnatinerved, 3–4 cm. long, 1·75 cm. broad, pubescent, thin, bright green above, paler beneath.

Nos. 2 and 3. Pinnatifid with three to five lobes, otherwise as in No. 1.

Limnanthes Douglasii, *R. Br.* (fig. 230).

Primary root tapering, small, furnished with lateral rootlets at the base, or these are adventitious on the end of the hypocotyl. Numerous strong adventitious roots also given off at the end of the hypocotyl close to the base of the cotyledons; annual.

Hypocotyl stout, subterranean, terete or more or less flattened, colourless, succulent, 1·4–2 cm. long.

Cotyledons petiolate, rotund-cordate, usually minutely emarginate, and marked at the apex with a small black scar, tipped with white, rather succulent, convex above and striate with broad shallow ridge-like veins, glabrous, deep green, subconcave beneath and minutely wrinkled, paler green; petiole semiterete, channelled above, dilated and sheathing at the base, seated rather deeply in the sinus of the leaf, glabrous. Lamina variable in size, 5–7 mm. long and as broad.

Stem herbaceous, annual and developed when about to flower.

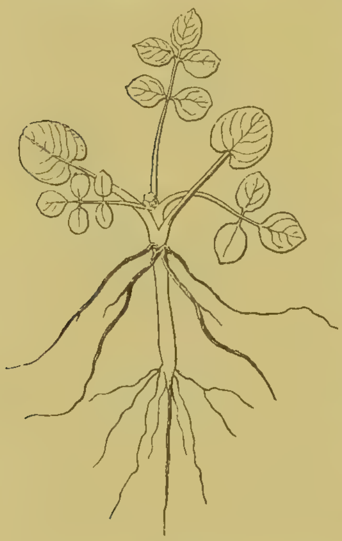

Fig. 230.
Limnanthes Douglasii.
Nat. size.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, rather succulent, simply or bi-pinnatifid or -sect; petioles semiterete, channelled above, dilated and sheathing at the base, glabrous.

No. 1. Ternately pinnatisect, often with five segments, which are shortly stalked but inarticulated, with the rachis rotund; mucronate, obscurely alternately veined.

Nos. 2 and 3. Pinnatisect, each with five or more segments; segments rotund, mucronate.

Ultimate radical leaves ovate or oblong-lanceolate, bipinnatisect; primary segments triangular or ovate, stalked; secondary segments, oval, mucronate, narrowed to the base, or rather indistinctly stalked.

Tropæolum majus, *L.* (fig. 231).

Primary root long, tortuose, succulent, colourless, giving off stout, fleshy, tortuose adventitious roots from near the top, which like the primary one are frequently notched or cut into as if by contact with some object.

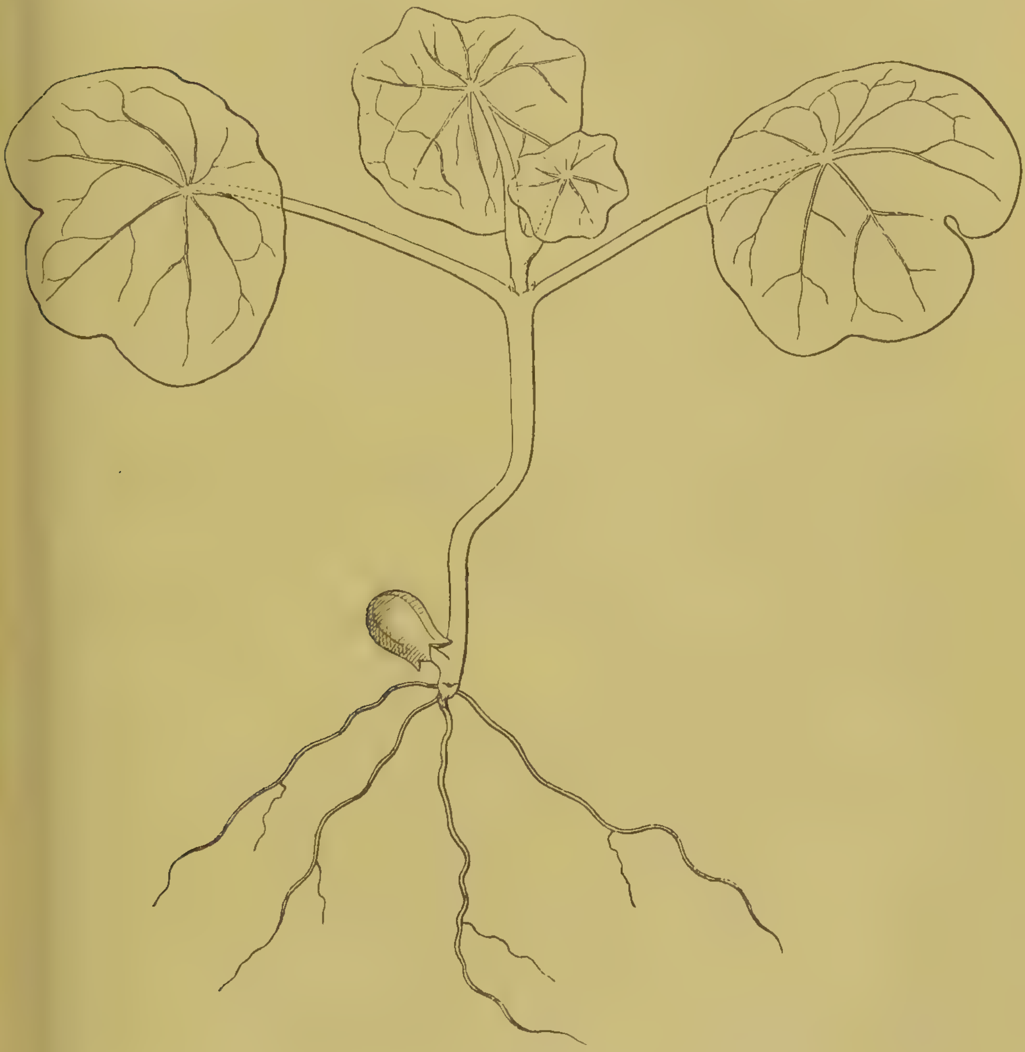

FIG. 231.—*Tropæolum majus.* Nat. size.

Hypocotyl undeveloped.

Cotyledons subterranean, large, fleshy, filling the testa, shortly petiolate and allowing the plumule to pass out between them on one side.

Stem herbaceous, perennial, succulent, flexuose, ultimately climbing or scrambling amongst other vegetation, glabrous, terete, pale green; first internode very variable in length according to the depth the seed is buried in the soil; second undeveloped, bringing two leaves opposite.

Leaves simple, cauline, alternate (first two opposite), exstipulate (first two stipulate), petiolate, peltate, radiately-nerved, lobulate, deep green above, with a narrow, red or yellow margin, pubescent on the nerves, ultimately glabrous, glaucous beneath, glabrous, and densely covered with sessile glands; petioles succulent, terete, glabrous, shining, tapering from a very stout base to the thinnest part immediately at the insertion of the blade; stipules of the first two leaves small, subulate, coloured like the stem, 1·5 mm. long.

Nos. 1 and 2. Opposite, peltate, with eight radiating nerves, shallowly trilobulate; lobes rounded, entire or minutely emarginate.

No. 3. Peltate, eight-nerved, seven-lobulate, with the eighth nerve running into the sinus at the base of the leaf; lobes shallow, rounded, emarginate.

Nos. 4 and 5. Similar to No. 3.

Ultimate leaves peltate, seven-nerved and lobulate, with two short nerves running into the broad shallow basal sinus; lobes broad, shallow, emarginate.

Tropæolum aduncum, *Sm.*

Primary root long, fleshy, colourless, with few lateral rootlets.

Hypocotyl and *cotyledons* as in T. majus.

Stem erect, otherwise as in T. majus; 1st internode in the specimen examined 4·6 cm. long, but variable according to conditions and capable of elongating considerably if the seed is deeply buried in the soil; 2nd internode varying from 1–3·5 mm. or more.

Leaves palmately or subpedately nerved and lobed, reticulate, glabrous, light green above, paler beneath; petiole terete, tapering upwards from a stout base, glabrous, pale green.

Nos. 1 and 2. Tripartite, with the lateral lobes again deeply bifid; middle segment oblong-oval, obtuse, entire; ultimate lateral lobes oblong, obtuse, entire.

No. 3. Tripartite; middle segment cuneate, trifid, with obtuse lobes; lateral segments again bifid with the anterior lobe more or less toothed, teeth obtuse.

Oxalis corniculata, *L.* (fig. 232).

Primary root long, tapering, with numerous long fibrous lateral rootlets.

Hypocotyl subterranean, stout, very short.

Cotyledons small, oblong-ovate, very obtuse, shortly petiolate, glabrous; lamina 3·5 mm. long, 3 mm. broad; petiole 1 mm. long.

Leaves radical, digitately trifoliolate, alternate, exstipulate, petiolate, glabrous above, ciliate at the margin, thinly silky beneath, folding down at night; petioles subterete, slightly flattened above, hairy, articulated by a broad base.

No. 1. Digitately trifoliolate; lateral leaflets obcordate, small; terminal leaflet broader than long, obcordate, larger than the lateral ones.

No. 2. Similar but larger.

Nos. 3–6. Leaflets broadly obcordate; lateral ones unequally emarginate with the smaller lobe on the posterior side, somewhat smaller than the terminal leaflet.

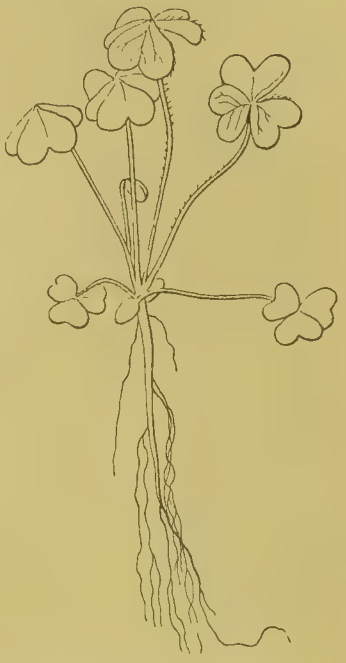

FIG. 232.—*Oxalis corniculata.* Nat. size.

Oxalis sensitiva, *L.*

Hypocotyl woody, erect, terete, hairy, pale brownish, thickened beneath the cotyledons and densely hairy, 1–1·3 cm. above the soil.

Cotyledons broadly ovate, obtuse, sessile, glabrous or slightly pubescent at the margin, 3·5 mm. long, 2·75 mm. broad.

Stem woody with undeveloped internodes.

Leaves abruptly pinnate, cauline, alternate, exstipulate, petiolate, thinly hairy above and dark green, glabrous, or thinly hairy beneath and often suffused with violet; petioles terete, hairy, articulated a little way above a stout base, excurrent between the leaflets with a small, subulate point; leaflets sessile, sensitive, folding downwards when the temperature is low or when stimulated by a touch, obliquely obovate, mucronulate in the first leaves.

No. 1. With one pair of leaflets.
No. 2. „ two pairs „
No. 3. „ three „ „

No. 4. With four pairs of leaflets.
No. 5. ,, five ,, ,,
No. 6. ,, seven ,, ,,
No. 7. ,, eight ,, ,,
No. 8. ,, nine ,, ,,
No. 9. ,, nine ,, ,,

Ultimate leaves abruptly pinnate with twelve to twenty or more pairs of leaflets, thinly hairy on both surfaces, and densely so on the midrib and petioles; leaflets varying from obliquely obovate and acute at the apex of the leaf to oblong and obliquely pointed with a small basal auricle on the posterior side, and then again to obliquely ovate and acute at the base of the leaf, where they are very small.

Impatiens parviflora, *DC.* (fig. 233).

Fruit a capsule, oblong-cylindrical or fusiform, glabrous, five-celled, many-seeded, dehiscing elastically with five valves, which roll spirally from the base upwards, at the same time scattering the seeds with some force.

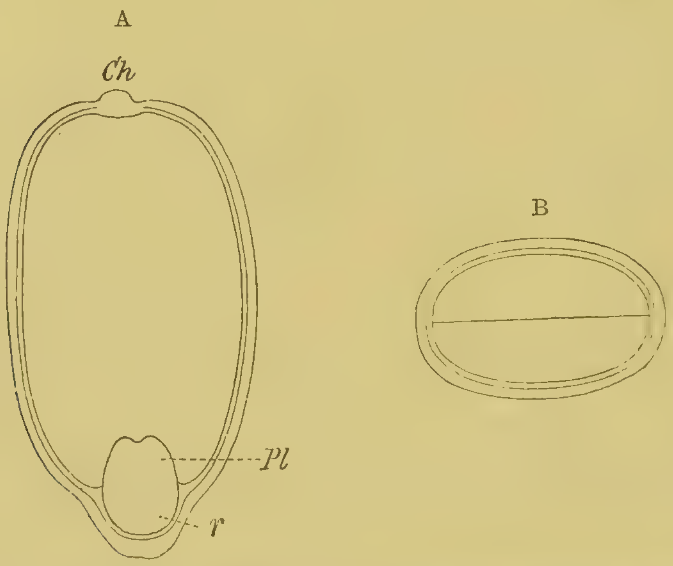

Fig. 233.—*Impatiens parviflora*, DC. A, longitudinal section of seed, × 10: *Ch*, chalaza; *Pl*, plumule; *r*, radicle. B, transverse section of seed, × 10.

Seeds obovoid, marked longitudinally with many short variously interrupted lines of little round protuberances: testa brown and rather thick; tegmen thin; micropyle and hilum basal: raphe ventral, conspicuous; chalaza apical, forming a small thickened knob externally to the testa, which is slightly indented at this point, thus apparently causing the emargination of the cotyledons.

Endosperm none, or forming an extremely thin membranous covering adhering to the inner surface of the testa.

Embryo straight, large, filling the cavity of the seed and conforming to it in shape, pale yellowish-white; cotyledons obovate-oblong, minutely emarginate, subcordate at the base, plano-convex, and rather fleshy; radicle very short, subglobose, stout, obtuse, much shorter than the cotyledons, which envelope half of it together with the plumule, the other half protruding.

Impatiens Balsamina, *L.* (fig. 234).

Primary root a short tap-root, succulent, colourless, unbranched, while many nearly horizontal rootlets spring from base of the hypocotyl.

Hypocotyl about 4 cm. long, 2 mm. thick, terete, succulent, glabrous, reddish near the base, greenish-white above.

Cotyledons shortly stalked, not quite equal, 2–2·5 cm. or more long, about 1·5 cm. broad, broadly ovate, cuneate at the base, apex rounded and emarginate, otherwise entire, obscurely palmatinerved with sunk midrib, convex, quite glabrous, light green above, paler below, somewhat succulent, not very persistent.

Stem erect, herbaceous, annual, stout, succulent, terete, densely pubescent, pale greenish-yellow; 1st internode 1·5–2 or 3 cm. long, 2·5 mm. thick; 2nd 2–3 mm. long.

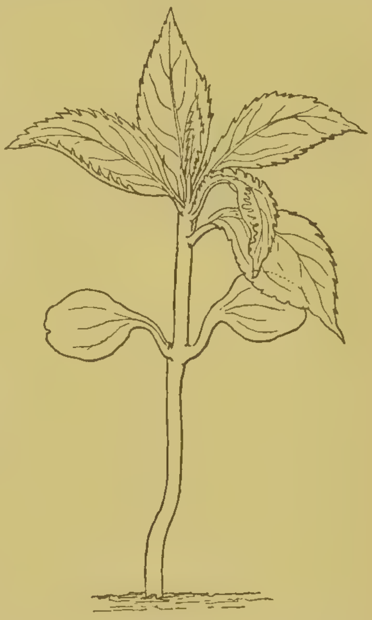
FIG. 234.—*Impatiens Balsamina.* Half nat. size.

Leaves simple, cauline, opposite or subalternate, petiolate; stipules obsolete; lamina lanceolate-elliptic, acute, acutely serrate, with small, subincurved, gland-tipped serratures, pale green above and shining, paler beneath, glabrous; nerves ascending and incurved, mostly alternate; petiole rather broad and widening towards the leaf, flattened above, convex and pubescent beneath, 2–3 mm. long; pubescence often extending on to the midrib of the leaf underneath.

1st to 3rd pairs lanceolate-elliptic, subacuminate, acutely serrate, cuneate or tapering at the base.

Impatiens fruticosa, *Lesch.* (fig. 235).

Hypocotyl succulent, terete near the base, obtuse-quadrangular just below the seed-leaves, glabrous, about 5 cm. long, 3–4 mm. thick, brownish.

Cotyledons very similar to those of I. Balsamina, obscurely trinerved, plane, fleshy, glabrous except the broad, reddish, slightly downy petiole, yellowish-green above, pale and shining beneath.

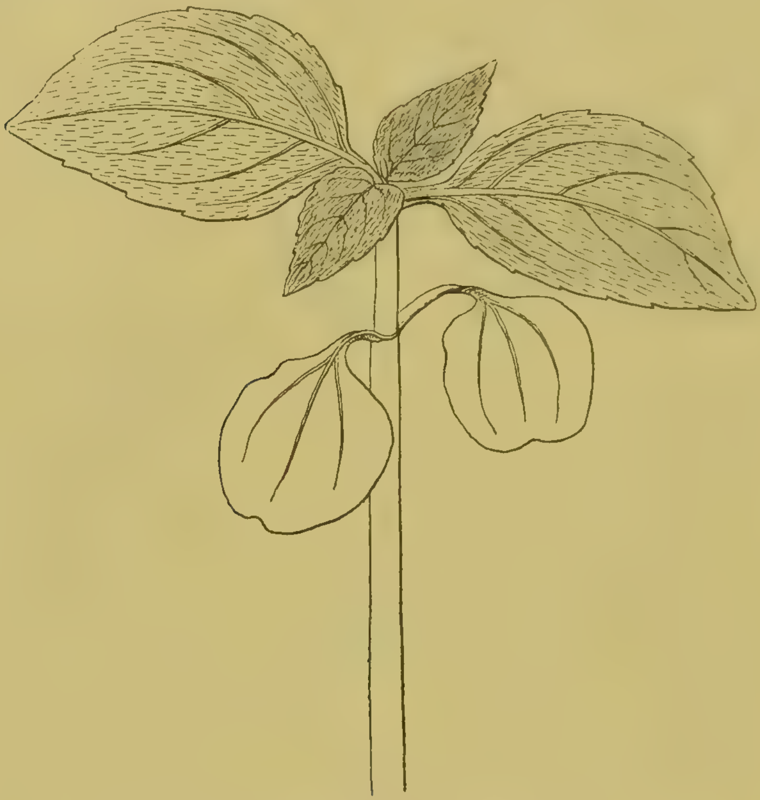

Fig. 235.—*Impatiens fruticosa.* Nat. size.

Stem succulent, terete, glabrous, light green; 1st internode 2 or 3 cm. long, 3 mm. (or more) thick, 2nd shorter.

Leaves.—Nos. 1–6. All alike; 5–6 cm. long, including the stout, hairy, short petiole; 2·5 cm. or more broad, ovate-elliptic, subacute at base, acuminate at apex, equally shallowly serrate, teeth mucronate; very distinctly penninerved, covered all over with a long soft pubescence (woolly to touch), bright green above, paler beneath.

RUTACEÆ.

Benth. et Hook. *Gen. Pl.* i. 278.

Fruit and Seed.—The carpels forming the ovary in this Order vary from three to five, rarely more or less as in Thamnosma and Atalantia, some species of which have dimerous ovaries. Whatever the number of carpels, they are united into an ovary with as many cells, except in Galipea, Zanthoxylum, and a few others, where the carpels are quite free. The ovules in each cell are very frequently two and superposed, but they also vary from three or four to many. They are pendulous, anatropous, or semianatropous. The raphe is ventral, the micropyle superior. The fruit varies greatly, but is capsular in the more typical Rutaceæ, opening by valves along the back or at the top as in Ruta, or breaking up into cocci which dehisce along the ventral suture. In many cases the exocarp breaks away elastically from a coriaceous, horny, crustaceous, or cartilaginous endocarp. In the tribe Toddalieæ the fruit is often baccate or drupaceous; instances of the latter are to be seen in Skimmia, Toddalia, and Phellodendron. The fruit of Ptelea, belonging to this tribe, is an orbicular samara, and in Helietta it consists of three samaras. That of the tribe Aurantieæ is most often pulpy with a coriaceous separable rind.

The seeds are oblong as in Ptelea trifoliata, or often reniform as in Monnieria, Ruta, and Bœnninghausenia, or obovoid as in Dictamnus, Skimmia, Citrus, and others. They are usually suspended from the top or the middle of the placentas. The testa is spongy, or more often crustaceous and shining as in Dictamnus, or it is pitted and granular. The outer coat is said to resemble an aril in Hortia. Endosperm is scanty or wanting in a large number of genera; but in the tribes Ruteæ, Boronieæ, Toddalieæ, and in most of the Zanthoxyleæ it is present in some quantity and fleshy, sometimes also oily. The embryo is very frequently curved according to the shape of the seed, or straight where the latter is obovoid. The radicle is superior and varies in length, being as long as the cotyledons in Ruta, with a reniform seed, and very short in Citrus and Dictamnus with obovoid seeds.

A very abnormal condition prevails in the seed of the Orange (Citrus Aurantium). Each contains from two to four embryos sufficiently developed to germinate and grow into plants, besides a similar or even greater number of very small ones that are unable to germinate. The large ones are fleshy, colourless, and nearly always have very unequal cotyledons of various shapes owing to mutual compression. There is usually one large cotyledon in each seed, belonging probably to the true embryo, while all the rest are smaller, and packed on to the face of the large one, completely filling the seed. The large cotyledon is often deeply concave with the others packed into the cavity. Strasburger states that the supernumerary embryos are developed by prolification from the tissue of the nucellus bordering on the embryo-sac.

A similar case occurs in Triphasia trifoliata, and is probably due to the same cause. The seed is exalbuminous as in the Orange, and generally contains two embryos of different sizes, with usually very unequal cotyledons. The larger cotyledon is concavo-convex or in some cases infolded at the sides. Three embryos are also not unusual, when one or other of the cotyledons is infolded and often more or less deeply lobed. This is due sometimes to one cotyledon becoming folded over the edge of the other.

Seedlings.—The seedlings I have met with all belong to the shrubby or arboreal types of Rutaceæ. Amongst them two leading types of cotyledons may be observed, namely, an aerial and a subterranean one. Those of Correa Colvillei are lanceolate, one-nerved, and taper to a very short petiole. The cotyledons of C. viridiflora differ in being narrower and linear-oblong. Ptelea trifoliata has more foliaceous, unequally oblong, finely crenulate cotyledons. Those of P. aptera differ in being proportionately longer and oblong-lanceolate. In Limonia acidissima we have a type that is intermediate between those having strictly aerial and strictly subterranean cotyledons. Although they are carried to a considerable height above the soil they are fleshy, pale green, and fall away early. Their function is evidently to constitute a storehouse for reserve-material and not to assimilate after germination. They are nearly always alternate, and two, rarely three in number. Murraya exotica agrees in the deciduous nature of its cotyledons.

The subterranean type may be represented by Calodendron capense, which has very large seeds and fleshy, shortly petiolate cotyledons. Those of Citrus Aurantium are much smaller, opposite or frequently alternate, colourless, fleshy, often compressed and of variable shape owing to the presence of several embryos in the seed, and strictly subterranean. In C. decumana they are oblong-elliptic, slightly falcate, plano-convex, fleshy, greenish-yellow, and both directed to one side of the stem as in some other cases where the cotyledons are subterranean. Ægle Marmelos has similar, but smaller, rounder seeds with cotyledons like those of the Pea.

There is considerable variation in the first leaves. The first one of Correa Colvillei is oval, the three succeeding ones roundly-elliptic. Those of C. viridiflora are obovate; and they differ but little in the adult stage, as the leaves of all the Correas are of very simple forms and quite entire. The leaves of Ptelea trifoliata are digitately trifoliolate from the first, or the primary leaf may be imperfect and have only two leaflets. Their margins are doubly and bluntly denticulate or crenulate, bearing some resemblance to those of the cotyledons, but the latter differ in being merely simply crenulate with distinctly rounded crenatures. The first leaf of P. aptera is simple and acuminate-lanceolate, followed by one that is digitately trifoliolate or imperfectly so, and that again by one having four or five leaflets. The first two or three leaflets of Limonia acidissima are ovate and alternate, opposite, or verticillate; the second and third digitately trifoliolate or pinnate, in other individuals with five opposite elliptic leaflets, and winged midribs. Murraya exotica differs in the first two leaves being opposite and triangular-ovate, and in the succeeding ones being pinnate with three or four alternate entire leaflets.

The first six leaves of Calodendron capense are reduced to small scales, a case of frequent occurrence where the seeds are large with subterranean cotyledons. Those that succeed are opposite, lanceolate, and entire, whereas those of the adult are acutely crenulate. The first two leaves of Citrus Aurantium are opposite, orbicular, emarginate, while succeeding ones are elliptic. C. decumana differs only by sometimes having the first four leaves in a whorl. The first and second of Ægle Marmelos are nearly opposite, broadly ovate, and doubly crenate.

Calodendron capense, *Thunb.*

Hypocotyl undeveloped.

Cotyledons large, thick and fleshy, occupying the whole interior of the seed, subterranean, and remaining in the seed till they are absorbed or decayed, shortly petiolate; petioles stout and subfleshy, their presence being necessary to allow the plumule to emerge from the seed.

Stem erect, terete, densely pubescent, pale green, soon becoming brownish, and dotted with small corky spots, ultimately woody and arborescent; primary internodes variable, with the primary leaves undeveloped.

Leaves simple, cauline, opposite or verticillate in threes, exstipulate, petiolate, decussate, alternately penninerved (with the nerves in the young plant at least irregularly disposed), reticulate, closely punctate, with pellucid glands, and a marginal, rather conspicuous row of larger ones, deep green above, much paler beneath, minutely pubescent on both surfaces; petioles very short, subterete, flattened or convex on the upper side, densely pubescent.

First six leaves in the specimen described reduced to scales.

Nos. 1–3. On the same level, falling away early, very small.

No. 4. Alternating with the others, small.

Nos. 5 and 6. Alternate or nearly opposite, green, lanceolate, obtuse, densely pubescent, about 3 mm. long.

4th to 11th pairs opposite.

4th pair foliaceous, lanceolate, obtuse, minutely auricled at the base.

5th pair much larger, lanceolate-elliptic, obtuse, slightly auricled at the base.

6th to 11th pairs lanceolate-elliptic or oblong-elliptic, obtuse, narrowed to both ends but especially to the base, where they are distinctly auricled. Younger ones developing unequally.

Correa Colvillei, *Hort.*

Primary root long, slender, flexuous, with much branched, long, lateral rootlets.

Hypocotyl 1·5–2·5 cm. long, 1 mm. thick, terete, glabrous, light green, firm.

Cotyledons nearly equal, 1·5 cm. long, ·5 cm. broad, obtuse, lanceolate, entire, with obscure nervation but distinct midrib, glabrous, dark green on the upper surface, pale on the under, coriaceous, with large brownish buds in the axil.

Stem firm, terete, with scattered brown stellate hairs, giving it a woolly appearance ; internodes only a few millimetres long, 1 mm. thick.

Leaves simple, entire, cauline, opposite or sometimes alternate in individual plants, exstipulate, shortly petiolate, more or less densely covered with a stellate pubescence, at least in the young state, obscuring the not very distinct venation, coriaceous, deep green above when the stellate tomentum is removed, whitish beneath ; petioles short, stellately tomentose.

Nos. 1 and 2. More or less opposite, shortly petioled, with swollen light brown buds in the axil of the woolly petiole ; lamina 1·25 cm. long, ·5 cm. broad, obtuse, elliptic, entire, with sunk midrib and covered with whitish dots formed by woolly stellate hairs, coriaceous, flat, with revolute margin, dark green above after disappearance of hairs, whitish below.

Nos. 3–5. Similar, but alternate and suborbicular.

Correa viridiflora, *Andr.*

Hypocotyl erect, terete, about 10–12 mm. above the soil.

Cotyledons linear-oblong, obtuse, entire, narrowed at the base to a short petiole about 15 mm. long, 2·5–3 mm. wide.

Ptelea aptera, *Parry.*

Hypocotyl about 2 cm. long, 1–1·5 mm. thick, firm, quadrangular at the base, terete just under the seed-leaves, verrucose, green.

Cotyledons subsessile, 3–3·5 cm. long, 1 cm. broad, oblong-lanceolate, acute at the base, obtuse at the apex, minutely crenate, with distinct midrib and verrucose, glandular surface, dark green above, rather paler beneath.

Stem terete but scabrous-verrucose, green ; 1st internode ·5 cm. long, 1 mm. thick, 2nd and 3rd 1 cm. long, less than 1 mm. thick.

Leaves compound, digitately trifoliolate or pinnately five-foliolate, cauline, alternate, exstipulate, petiolate, alternately penninerved with the nerves somewhat incurved towards the tip, reticulate, coriaceous, glabrous, deep green above, paler beneath, with characteristically strong-smelling stems and leaves; petioles semiterete, channelled above.

No. 1. 2·5–3 cm. long (including petiole 5 mm.), 6–8 mm. broad, lanceolate, acuminate at both ends, crenulate or bicrenulate, pinnatinerved, rugose, firm, not very thick, dark green above, light shining green beneath, with a tomentose bud in axil of petiole.

No. 2. Similar, but larger, and with a small leaflet at base of blade.

No. 3. Similar, ternately pinnate with large terminal leaflet, sometimes two large and two small leaflets.

Ptelea trifoliata, *L.*

Hypocotyl finely and minutely pubescent, 8–15 mm. long.

Cotyledons unequally oblong, obtuse, shortly petiolate, finely crenulate, deep green, rather opaque, alternately and ascendingly penninerved, glabrous except on the midrib beneath; lamina 10–15 mm. long, 5–7 mm. broad; petiole slightly grooved above, pubescent beneath only, 2–2·75 mm. long.

Stem pubescent with curved or curled hairs, ultimately woody; 1st internode 3·5–5·5 or 6 mm. long, 2nd ·5–1·25 mm.

Leaves trifoliolate, hairy on the midrib and margins of leaflet and petiole when young, ultimately glabrous; leaflets alternately and ascendingly penninerved; petioles semiterete, channelled above.

Nos. 1 and 2. Usually trifoliolate; terminal leaflet elliptic, obtuse, irregularly and obtusely dentate; lateral leaflets smaller, sometimes very much smaller, oblong-elliptic, obtuse, irregularly and obtusely dentate. Sometimes one of the lateral leaflets of the first leaf is wanting.

Limonia acidissima, *L.*

Hypocotyl becoming woody, erect, terete, finely pubescent, wiry, pale green, 2·3–2·9 cm. long.

Cotyledons two, rarely three, mostly alternate, fleshy, oblong, obtuse, pale green, finely pubescent, sessile or subsessile, somewhat notched at the base.

Stem woody, erect, terete, finely pubescent, wiry; 1st internode variable, 1·6–2·3 cm. long; 2nd 2 mm.; 3rd 3 mm.; 4th 7·5 mm.

Leaves compound, cauline, alternate, exstipulate, petiolate, glabrous, deep green, shining, pubescent on the nerves beneath when young, permeated with translucent glands, doubly crenulate, emarginate; petioles subpubescent, winged with a prominent midrib, and tapering towards the base.

Nos. 1 and 2. Unifoliolate, frequently also Nos. 3 and 4. All alternate at greater or less distances from each other, or in pairs, or all four verticillate, ovate, obtuse, emarginate, articulated at the top of their petioles, or the lowest pair articulate at the base only.

Nos. 3 and 4. Frequently digitately trifoliolate, the terminal leaflet being lanceolate-elliptic, attenuate at the base; the lateral leaflets arise by segmentation from the terminal one.

No. 4. In some instances five-foliolate; the rachis between the basal and next pair of leaflets winged and tapering towards the base in the same way as the primary petiole; leaflets sessile, lanceolate-elliptic, emarginate, minutely and doubly crenulate, smaller than the leaflets of unifoliolate leaves.

Murraya exotica, *L.*

Stem woody, pubescent and verrucose when young, becoming corky; 1st internode 3·1 cm. long; 2nd 1·4 cm.; 3rd 7 mm.; 4th 4 mm.; 5th 5·5 mm.

Leaves compound, imparipinnate, cauline, alternate (Nos. 1 and 2 opposite and simple), exstipulate, petiolate, evergreen, glabrous, deep green.

Nos. 1 and 2. Triangularly ovate, obtuse, entire, penninerved, with a sunk midrib, convex above, provided like the rest with internal resin or oil glands; petiole deeply channelled above, 4 mm. long.

No. 3. Pinnately trifoliolate; lateral leaflets rotund-elliptic; terminal one elliptic; all obtuse, coriaceous; petiole flattened above, pubescent, subverrucose; rachis between leaflets similar to petiole and articulated with the leaflets.

No. 4. Similar to No. 3, but much smaller.

No. 5. Imparipinnate; leaflets four, alternate, irregular in size and shape, oblong or lanceolate, obtuse, entire—the terminal one much the largest.

No. 6. Imparipinnate; leaflets four, irregular oval, oblong, or subelliptic, obtuse.

Ultimate leaves three- to five-foliolate; leaflets alternate, ovate, subacuminate, emarginate, slightly narrowed to the base, coriaceous, evergreen, petiolulate, shining; petioles, petiolules, and midrib pubescent on both surfaces.

Citrus Aurantium, *Risso.*

Primary root stout, tapering, twisted, furnished after a time with a few lateral rootlets, longitudinally ridged and furrowed, at least when dry.

Hypocotyl subterranean, short, stout, curved, longitudinally ridged, colourless, 2–3·5 mm. long.

Cotyledons two, opposite or frequently alternate, colourless, fleshy, not leaving the testa, but very often compressed and shapeless owing to the presence of two, three, or four embryos in the seed.

Stem woody, erect, terete (striate when dried and somewhat twisted), pale green, glabrous or minutely pubescent; 1st internode 2·5–4 cm. long; 2nd, and sometimes the 3rd and 4th, undeveloped, or the 3rd 3 mm. and the 4th 2·25 mm. long.

Leaves simple, cauline, alternate, exstipulate, petiolate, evergreen, shining, coriaceous, thickly dotted with immersed glands, strongly odoriferous when bruised, glabrous.

Nos. 1 and 2. Generally opposite by the non-development of the internode, more or less obliquely obcordate and appearing deformed very shortly petiolate.

Nos. 3 and 4 (in specimen examined). Alternate, elliptic, obtuse, obsoletely serrate, minutely emarginate, with alternate, ascending, lateral nerves; petioles channelled above, narrowly winged, articulated with the stem below and the leaf above.

Ultimate leaves oblong-ovate, acuminate, emarginate, minutely and obsoletely serrate, pellucidly punctate, with a thin marginal line of larger glands; lamina articulated with the winged petiole, which is ovate in outline, with a short, stout, not winged base.

Citrus decumana, *L.*

Hypocotyl very short, subterranean.

Cotyledons subterranean, and remaining in the seed till they decay, oblong-elliptic, obtuse, plano-convex, fleshy, sessile and both directed to one side, greenish-yellow above, yellowish beneath, somewhat falcate, 13 mm. long, and 6 mm. wide.

Stem soon becoming woody, covered with a short, very fine pubescence; 1st internode 5–5·5 cm. long; the one to three following ones suppressed, or from two to four of the leaves on the same level; succeeding ones again elongated.

Leaves as in C. Aurantium.

1st pair opposite, orbicular, emarginate, subsessile, not articulated with the short petiole, crenate.

2nd pair often on the same level as the first two, so that there is a whorl of four. When distinct oblong or elliptic, obtuse, otherwise like the two preceding.

5th (where the first four are whorled) elliptic, cuneate at the base.

6th obovate-elliptic, more elongate and cuneate at the base, with a swelling of the midrib some distance above the base, corresponding to articulation.

7th leaf ovate, bluntly pointed, articulated with an oblanceolate, winged petiole, obsoletely crenate.

Ægle Marmelos, *Corr.*

Hypocotyl short, subterranean.

Cotyledons subterranean, fleshy, plano-convex, rotund-oval in outline, 7·25 mm. long including the very short petiole, 5·25 mm. broad.

Stem erect, terete, woody, pubescent, pale green; 1st internode 3·1 cm. long; 2nd 1 mm.; 3rd 8 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate or subsessile, glabrous, alternately penninerved and reticulate, perforated with glands, deep green above, paler beneath, tapering to the base; petioles short or none.

Nos. 1 and 2. Broadly ovate, obtuse, emarginate, doubly crenulate, nearly opposite.

No. 3. Elliptic, obtuse, emarginate, doubly crenulate.

Further stages show leaves obovate and rotund-elliptic, large, obtuse, emarginate, doubly crenate.

Ultimate leaves digitately trifoliolate, lateral leaflets ovate or ovate-elliptic, crenate; terminal one slightly larger, elliptic, obtuse, emarginate, crenate, or obscurely doubly crenate, penninerved and reticulate.

SIMARUBEÆ.

Benth. et Hook. *Gen. Pl.* i. 306.

Fruit and Seed.—The ovary in this Order is made up of two to five carpels, rarely one as in Cneoridium and Amaroria, and is more or less deeply two- to five-lobed, or the carpels are altogether free. When the carpels cohere they form an ovary with as many cells as there are carpels; the cells in Cneorum tricoccum are sometimes spuriously bilocellate with superposed ovules and cavities. The ovules are generally solitary, rarely four to five as in Dictyoloma or numerous as in Kœberlinia; and they are pendulous, anatropous, amphitropous, or variously curved. The raphe is ventral, and the micropyle superior as a rule, but there are cases where it is inferior as in Suriana and Cneoridium. In Dictyoloma and Kœberlinia they are numerous, ascending, with the raphe dorsal. The fruit is drupaceous or dry and indehiscent, sometimes with a woody endocarp as n Cneorum and Simaba, or it is capsular and dehiscent as in Dictyoloma and Brunellia, or samaroid as in Ailanthus and Soulamea. The seeds are generally solitary and pendulous, with a membranous or sometimes crustaceous testa as in Cneorum. Endosperm is copious and fleshy, or scanty, or altogether wanting. The embryo is straight with flat or plano-convex cotyledons, more or less semiterete. In rare cases they are twisted, and in the large-seeded Simaba they are thick, fleshy, and plano-convex.

A longitudinal section of one of the cocci of Cneorum tricoccum shows the curious manner in which the seed and embryo are curved so as to accommodate themselves to the interior of the bony endocarp. The testa is not folded, while the tegmen containing the fleshy endosperm and the embryo is doubled up on itself. A transverse section of another coccus shows two seeds occupying the cavity. In Dictyoloma the seed is winged. The fruit of Ailanthus glandulosa consists of one to five samaras, but, in Britain at least, only one is usually brought to maturity although two are not unusual. The samara is oblong or oblanceolate, nearly straight on the ventral edge with a small indentation above the middle, where the solitary seed is located, and more or less rounded on the back, laterally compressed and membranous. The seed lies in a slightly elevated cavity of the samara, and is obliquely pendulous, anatropous, and laterally flattened. The embryo lies in the broader plane of the seed, embedded in endosperm, which it nearly equals in length and width. The cotyledons are obovate, nearly flat, and conform to the shape of the seed, with their edges to the placenta. The superior radicle is several times shorter than the cotyledons.

Seedlings.—This Order is mainly tropical, and with exception of a few species of some medicinal importance, together with the hardy Ailanthus glandulosa and Cneorum tricoccum, are seldom seen in a living state in this country, consequently seedlings seldom come under observation. The cotyledons of

Cneorum tricoccum are sessile, linear, one-nerved, and subcoriaceous. The primary leaves are lanceolate-elliptic or oblong, obscurely penninerved, and entire, as they are in the adult state.

The cotyledons of Ailanthus glandulosa are also aerial, foliaceous, obovate, and shortly petiolate. The first two leaves are pinnately trifoliolate, and remind one of those of Rhus typhinus. Young trees are vigorous; the leaves vary from eighteen inches to three feet in length, with numerous pairs of leaflets.

Ailanthus glandulosa, *Desf.*

Fruit consisting of one to five samaras comparable to those of Fraxinus. Samaras indehiscent, thin or membranous, strongly winged, oblong or oblanceolate, obtuse, tapering downwards and suddenly narrowed to the receptacle on the dorsal edge at the base, notched on the ventral aspect close to the attachment of the seed, and elevated into a hemispherical swelling where the latter is situated.

Seed obovate, biconvex, flattened, conforming to the cavity pretty closely when fresh, but shrinking considerably when dry, pale whitish, descending obliquely; hilum a little below the pointed upper end, and on the ventral edge of the seed; raphe ventral; chalaza pale brown at the lower and broader end of the seed; testa thin, membranous.

Endosperm moderately copious, fleshy, surrounding the embryo.

Embryo straight, colourless, large, almost as long as the endosperm.

Cotyledons broadly obovate, slightly auricled at the base so as to accommodate the radicle; the latter stout, obtuse, several times shorter than the cotyledons, embedded in endosperm close to the pointed end of the seed, and consequently a little above the hilum.

A. glandulosa, *var.* rubra.

Hypocotyl erect, terete, glabrous, 2·3–3 cm. long, light green or colourless.

Cotyledons coriaceous, broadly obovate, obtuse, entire, shortly petiolate, glabrous, light green, distinctly and alternately pinnatinerved.

Stem erect, herbaceous, ultimately woody, slightly flattened, covered with fine hairs, light green; 1st internode 5–8 mm. long.

First leaves compound, trifoliolate, petiolate, exstipulate; terminal leaflet acuminate, subacute, entire; lateral ones slightly toothed, ultimately glabrescent, petiolulate, light green, alternately pinnatinerved; petioles ribbed or striated, covered with short, glandular hairs; the young leaves are also covered with fine silky hairs near their edges.

Cneorum tricoccum, *L.*

Fruit separating from the gynophore into three cocci, each ovoid, with a free projecting base, which is by far the thickest part, and from which it gradually tapers to the tip, where it is crowned by the base of the persistent style; one- to two-seeded, indehiscent; epicarp deep green before maturity, and retaining that colour if picked; mesocarp fleshy, moderately thin; endocarp very thick, bony, brown when dry, and deep reddish-brown when moist.

Seed obovoid, suspended obliquely from near the top of the inner angle of the cell; testa thick-walled, crustaceous, adhering closely to the endocarp and deeper than it in colour; tegmen thin, membranous, adhering more to the endosperm; micropyle and hilum basal at the upper end of the seed; chalaza at the apex of the curve of the endosperm, leaving a brown mark there when the latter containing the embryo is removed from the testa.

Endosperm copious, fleshy, white, curved nearly in the middle so as to bring the apex near to a level with the basal end containing the radicle, surrounding the embryo.

Embryo much curved, surrounded on all sides by endosperm, colourless when moist; cotyledons linear, obtuse, entire, plano-convex, curved, about equal in length to the radicle, accumbent, and placed with their edges to the placental axis or slightly obliquely to it; radicle cylindrical, obtuse, less curved than the cotyledons, which about equal it in length, extending a little beyond the cotyledons and nearer the hilum.

Seedling.

Primary root long, wiry, tapering, colourless, with a few lateral rootlets.

Hypocotyl woody, erect, terete, glabrous, green above ground, 1·5–2 cm. long.

Cotyledons sessile, linear, plano-convex, or with the sides somewhat upturned, making them grooved, subacute, cuspidate, or suddenly and obtusely pointed, subcoriaceous, not very persistent, deep green above, paler beneath, 1·5 cm. long, 2·5 mm. broad.

Stem shrubby, flexuous, much branched from an early stage onward, terete, minutely pubescent, green; 1st internode 7 mm. long; 2nd 4·5 mm.; 3rd 3 mm.; 4th 4 mm.; 5th 5·75 mm.

Leaves simple, entire, cauline, alternate, exstipulate, sessile, coriaceous, evergreen, with a prominent midrib on both surfaces, glabrous or minutely pubescent at the base of the midrib beneath, slightly revolute at the margin, shining, deep green above, paler beneath.

Nos. 1–5. Lanceolate-elliptic, obtuse, gradually larger from the base upwards.

Ultimate leaves lanceolate-oblong, obtuse, mucronate, about 3–4 cm. long.

OCHNACEÆ.

Benth. et Hook. *Gen. Pl.* i. 316.

Fruit and Seed.—The ovary is central or excentric, short and two- to ten-lobed, or elongated and one- to ten-celled, with axial or parietal placentation, or the ovules are inserted on the inflexed margins of the carpels. Instances of the short ovary are seen in Gomphia and Ochna, a few of which are grown as stove-plants in this country. The carpels are seated on a large receptacle, round the sides of which they are arranged and connected at the extreme base with the central style. They are so widely separated in the ripe fruit of Ochna that they appear apocarpous. The usual number of ovules in each cell is one or two, sometimes many; they are ascending and anatropous, with an inferior micropyle and ventral raphe, rarely pendulous with a superior micropyle. A one-celled ovary with three parietal placentas occurs in Wallacea.

The fruit consists of three to ten drupes arranged in a whorl, as in Ochneæ, with one ovule in each cell, and exalbuminous seeds. In Euthemis it consists of five portions having a woody endocarp, and albuminous seeds. It is capsular in the tribe Luxemburgieæ with albuminous seeds. Where present the endosperm is fleshy. The testa is membranous in most cases, but is winged in Luxemburgia, thick in Wallacea, and produced into a linear sheath in Cespedesia.

The embryo is generally straight and terete, but there are exceptions, especially amongst the exalbuminous seeds. The cotyledons are very thick and plano-convex in Ochna, Gomphia, and Elvasia, with an exceedingly short radicle. Both the seed and the embryo are annular in Brakenridgea, while the cotyledons are linear. Where endosperm is wanting, as in the Ochneæ, the embryo conforms in outline to that of the seed; and when the latter is solitary it is large, and conforms to the cavity of the carpels. In albuminous seeds the embryo where known is generally slender.

A good instance of the exalbuminous type is Ochna Kirkii.

Seedlings.—The cotyledons of Ochna Kirkii (fig. 236) are thick, fleshy, subterranean, and represent the exalbuminous type. Here it will be noted that the first two leaves are reduced to scales.

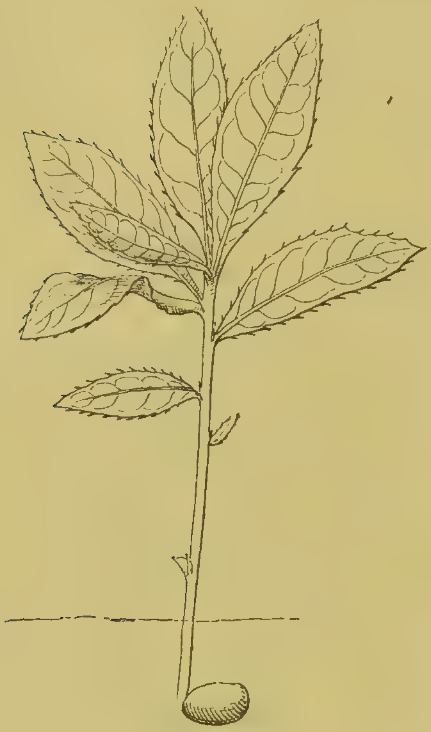

Fig. 236.
Ochna Kirkii. Nat. size.

Ochna Kirkii, *Oliv.*

Fruit of three to ten drupes arranged around a central, large, elevated torus or disk, with a gynobasic style, best seen in the young condition; drupes shortly oblong, slightly laterally compressed, fixed to the torus by an oblique lateral scar near the base, and diverging outwards, glabrous and shining black when mature, and falling away separately; walls of drupe comparatively thin with very little pulp; endocarp subcrustaceous, dull greenish, and reticulated internally when fresh.

Seed solitary in each cell, large, and conforming to the interior of the drupe, which it closely occupies; testa thin, membranous, brown; hilum and micropyle contiguous, close to or at the lateral scar of the drupe, where it is fixed to the axis.

Seedling (fig. 236).

Hypocotyl short or none, subterranean.
Cotyledons fleshy, plano-convex, filling the seed, which fills the

carpel, remaining in the ground attaching the seedling to the fruit till the latter is exhausted.

Stem woody, shrubby, erect, terete, pale green, glandular-pubescent; 1st internode 1·2 cm. long; 2nd 1·4 cm.; 3rd 5 mm.; 4th 6 mm.; 5th 2·5 mm.; 6th 1·5 mm.; 7th to 10th crowded or undeveloped.

Leaves simple, glandular-ciliate, serrate, cauline, alternate, stipulate, subsessile, thickened at the base and articulated with a raised knob or projection of the stem, glabrous, deep shining green, and finely reticulate above, paler beneath and shining; midrib prominent on both surfaces; stipules small, brown, scarious, rigid, subulate, connate by their edges for two-thirds of their length or throughout, and lying between the leaf and the stem.

Nos. 1 and 2. Reduced to small, subulate scales.

No. 3. Small, foliaceous, oblanceolate-linear.

No. 4. Much larger, lanceolate, serrulate.

Nos. 5–9 inclusive. Lanceolate-elliptic, acute, serrulate.

BURSERACEÆ.

Benth. et Hook. *Gen. Pl.* i. 321.

Fruit and Seed.—The typical Burseraceæ have two to five carpels, united to form an ovary with the same number of cells. Amyris and Hemprichia are exceptional, inasmuch as the ovary is one-celled. The ovules are attached to an axial placenta, above the middle and generally near the top, and are pendulous, anatropous, collateral, with a ventral raphe and superior micropyle; rarely ascending. The usual number is two, but there is only one in each cell of Filicium, and one in the unilocular ovary of Hemprichia. The fruit is drupaceous, consisting of two to five connate or separable pyrenes. The epicarp is persistent, or splits open by two to four valves, leaving the pyrenes naked. The latter consist of the woody or bony endocarp. In some cases, however, the endocarp is not bony, and may even dehisce irregularly.

The seeds are generally if not always solitary in each loculus, by abortion, very large, and exalbuminous with a membranous testa. The seed of Santiria is peltate, and the fruit of species of that genus grows very unequally, so that the style is sometimes turned on one side till close to the pedicel. As might be expected, the seed generally conforms in shape to the loculus of the bony endocarp. The embryo is large, and occupies the whole of the seed. The cotyledons are in most cases foliaceous, aerial, and more or less contorted or twisted so as to occupy the whole of the available space; the short radicle is superior. Hedwigia and Amyris have thick, fleshy, plano-convex, or almond-shaped straight cotyledons.

Some genera present still more remarkable exceptions; such as Trigonochlamys, which has deeply lobed cotyledons; Santiria, with irregularly cut cotyledons; Bursera, where they are sometimes trifid; and Boswellia, where they are multifid. In Canarium commune they are tripartite, auricled at the base, where they clasp or sheathe the radicle, which is stout, fleshy, and projects slightly beyond them. Two of the cotyledonary lobes occupy the dorsal aspect of the seed, while the rest occupy the ventral part, and are confusedly contorted or twisted one with another. In the mature seed they are soft, fatty, and taste like the kernel of the Brazil Nut (Bertholletia excelsa). One species of Bursera has the cotyledons curved like a horse-shoe, while the embryo of Crepidospermum Sprucei is green and similarly curved.

Seedlings.—The Order consists of about 150 species, natives of the tropical parts of both hemispheres, and, not being very popular for horticultural purposes, seedlings are seldom to be seen in this country. I have only met with those of Canarium strictum (fig. 237).

In this species the first and several succeeding leaves are simple, ovate, acuminate, and serrate. The adult ones are imparipinnate, with opposite and very coriaceous, serrate leaflets. A few species have leaves consisting of one or three leaflets in the adult stage, and in some cases the leaflets are entire.

Canarium commune, *L.*

Fruit drupaceous, ovoid or ellipsoid, trigonous, three-celled but only one-seeded by abortion of all the ovules except one, which conforms to the single cell, outgrowing and crushing the others; epicarp fleshy, thin ; endocarp bony, 3–4·5 mm. thick, brown and nearly smooth externally, smooth or slightly uneven internally, shining red, closely amalgamated with the small cord-like axis.

Seed oblong, compressed, almond-shaped, two-edged, even or variously indented, furrowed sometimes along the ventral aspect by pressure against the axis ; testa thin, brown, easily broken ; hilum round, near the apex on the ventral aspect of the seed and collateral with the remains and point of attachment of the abortive ovule ; raphe ventral, double, forming a slightly depressed, black line, diverging from the hilum.

Endosperm wanting.

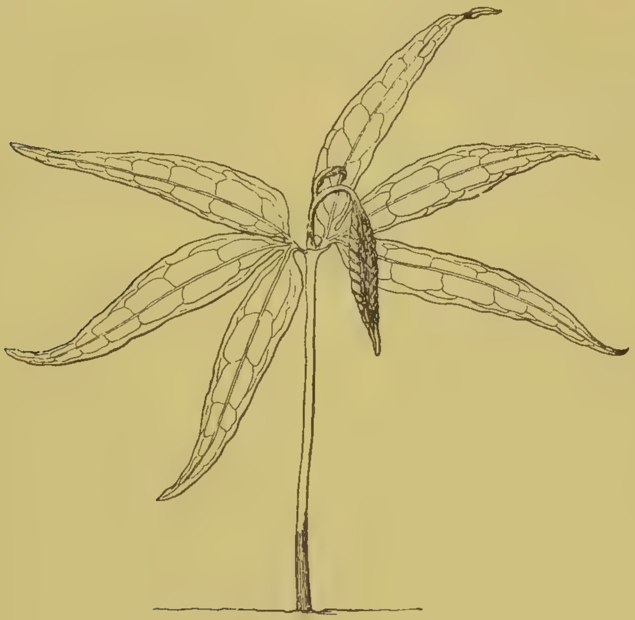

FIG. 237.—*Canarium strictum.* Half nat. size.

Embryo large, fleshy, conforming to the shape of the seed, fatty, pale yellowish-white, soft, and tasting like the kernel of the Brazil Nut ; cotyledons tripartite, depressed at the base and grasping the radicle, then ascending, oblong—two segments occupying almost the whole of the dorsal aspect with their tips incurved and grasping the top of the other lobes, which are also decurved at the base and then ascend on the ventral aspect, becoming confused and variously twisted together ; radicle stout, fleshy, projecting slightly beyond the cotyledons and compressed antero-posteriorly.

Canarium strictum, *Roxb.* (fig. 237).

Hypocotyl 6–8 cm. long, 2–3 mm. thick, terete, succulent, glabrous, pale green.

Cotyledons stalked, tripartite; segments 5–6 cm. long, 1–1·25 cm. broad, the middle one lanceolate, lateral ones oblique-lanceolate, long-acuminate, entire, with slightly undulate margin, distinct midrib, and alternate, incurved nerves and veins, quite glabrous, light shining green, somewhat persistent.

Stem terete, shallowly ridged and furrowed, covered with a dense patent pubescence, pale green, becoming woody; 1st internode 2 cm. long, 1·5 mm. thick; 2nd internode 6 mm. long.

Leaves cauline, alternate, exstipulate, petiolate; petiole terete, slightly channelled above, tapering upwards, ascending, densely pubescent, 2·7 cm. long; lamina ovate, acuminate, or almost oval with an acuminate, subacute point, serrate, penninerved, with alternate ascending nerves ultimately curving forwards, coarsely hairy and pale green on both surfaces, shining above, horizontal.

MELIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 327.

Fruit and Seed.—The carpels vary from three to five, and are united into an ovary of as many cells. The most frequent number of ovules is two, and they are collateral or superposed, pendulous or ascending, with a ventral raphe and a superior micropyle. Exceptions to the above characters occur in Elutheria, which has a one- or imperfectly four-celled ovary; and in Chisocheton, which has one ovule in each cell; the same thing sometimes occurs in Aglaia, Milnea, Amoora, and Guarea. The ovary of Turræa varies in different species with from five to twenty loculi. Numerous ovules occur in each cell of the ovaries of the species belonging to the tribes Swietenieæ and Cedreleæ. The fruit is baccate, capsular, or less often drupaceous. Instances of the latter occur in Melia, Mallea, and Owenia.

The seeds are albuminous or exalbuminous, varying however in the same genus in some cases; the endosperm when present is fleshy. The testa is drawn out into a wing in Soymida, Chickrassia, Cedrela, Chloroxylon, and Flindersia. A curious case occurs in Swietenia and Khaya, where the cotyledons and endosperm are closely adherent. The cotyledons are fleshy and more or less flattened. They are bipartite in Milnea apiocarpa and others; in several cases they lie transversely to the seeds; and in Carapa, Trichilia, and some others the cotyledons are conferruminate. They are unequal-sided in Chickrassia, which has flattened seeds winged on the back. The flattening is due to the mutual compression of the large seeds, which vary from two to five in each cell of the capsule. An aril is present in many genera, and in some cases it is united or confluent with the testa; but more frequently it simply surrounds the whole seed.

Seedlings.— This Order numbers some 270 species, but few are of frequent occurrence in this country, with exception perhaps of Melia Azedarach (fig. 238). There are several types of seedlings. In Walsura piscidia (fig. 239) the cotyledons are fleshy, shortly petiolate, and strictly subterranean. The first pair of leaves in Melia Azedarach is tripartite, with cuneate, cut, or deeply toothed segments. Succeeding ones vary in the amount of division till they become bi- to tri-pinnate. Although the first four are in opposite pairs, the rest are alternate. A noticeable point in Walsura piscidia is that the first pair of leaves is small and scaly, followed by two pairs of small but foliaceous ones. Succeeding ones to the ninth are larger, alternate, and entire. Some species of Walsura have trifoliolate or pinnate leaves.

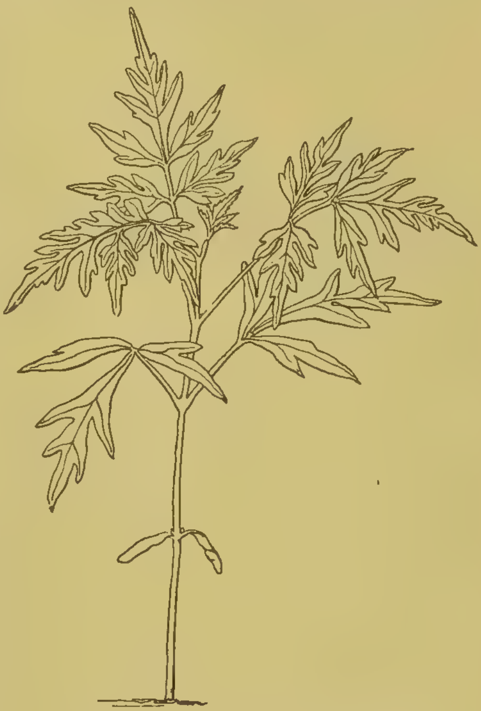

FIG. 238.—*Melia Azedarach.* Half nat. size.

Melia Azedarach, *L.* (fig. 238).

Hypocotyl erect, terete, pale green, pubescent, about 3·4 cm. above the soil.

Cotyledons linear-oblong, obtuse, narrowed to a short petiole, glabrous except the upper side of the petiole, ultimately revolute at the sides, falling away early, about 1·2 cm. long including the petiole, 2·5 mm. broad.

Stem erect, terete, pale green, covered with short upwardly incurving hairs; 1st internode 1·65 cm. long; 2nd 1·5 cm.; 3rd 1·1 cm.

Leaves compound, cauline, alternate (1st and 2nd and sometimes the 3rd and 4th in almost opposite pairs), exstipulate, petiolate, thinly and finely pubescent above, slightly revolute at the margin, deep or bright shining green above, pale and glabrous beneath; petioles convex on the back, with a slender channel on each side of the prominent midrib on the upper face, pubescent with upwardly incurving hairs.

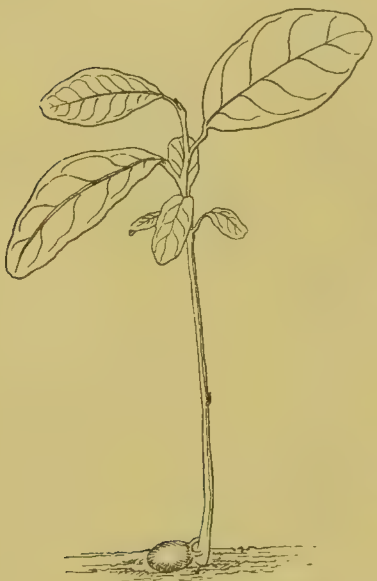

Fig. 239.—*Walsura piscidia.* Nat. size.

Nos. 1 and 2. Subopposite, tripartite; lateral segments oblong-lanceolate, subacute, with a large tooth on the middle of the posterior side; terminal lobe cuneate-rhomboid, pinnatifid.

Nos. 3 and 4. Alternate or subopposite, pinnate, pinnatifid; basal pair of leaflets ovate, acute, deeply pinnatifid at the base and less deeply so or toothed upwards; terminal leaflet triangular pinnatipartite at the base and pinnatifid upwards, with the basal and larger segments lobed, the rest entire.

No. 5. Pinnately five-foliolate; basal pair of leaflets pinnatipartite at the base and less deeply cut upwards; middle pair ovate, cuneate at the base, pinnatifid; terminal leaflet triangular, acuminate, cuneate, and pinnatipartite at the base, becoming gradually less deeply cut upwards.

Ultimate leaves bipinnate; leaflets ovate, acuminate, coarsely and obtusely serrate, frequently lobed or segmented on the posterior basal side.

Walsura piscidia, *Roxb.* (fig. 239).

Hypocotyl generally subterranean.

Cotyledons fleshy, remaining in the seed.

Stem woody, erect, terete, pubescent, soon becoming brown and throwing off the epidermis; 1st internode 2·9 cm. long; 2nd 3·45 cm.; 3rd 1·5 mm.; 4th 3·75 mm.; 5th 1·5 mm.; 6th 2·25 mm.; 7th 5 mm.; 8th 6 mm.

Leaves simple, ultimately pinnate, cauline, alternate, exstipulate, petiolate, glabrous, coriaceous, penninerved, deep green above, paler beneath; petioles channelled above, pubescent, short.

Nos. 1 and 2. Opposite, reduced to small, brown scales.

Nos. 3–6. Small, aggregated, oval, emarginate, entire.

Nos. 7–9. Much larger, oval, emarginate, otherwise entire.

ILICINEÆ.

Benth. et Hook. *Gen. Pl.* i. 355.

Fruit and Seed.—The Order contains some 150 species, all of which belong to the genus Ilex with four exceptions. The ovary is mostly made up of three to five carpels, rarely six to eight as in some species of Ilex. The three species of Byronia however vary with ten to eighteen carpels. The ovules are solitary or geminate in different species of Ilex, pendulous from the tip of axile placentas, collateral and anatropous; in Nemopanthes they are solitary. The raphe is dorsal, rarely lateral, with a superior radicle. The fruit is drupaceous, with a very thin succulent layer surrounding a bony, crustaceous, or rarely cartilaginous endocarp. When the carpels are mature they are separable into as many pyrenes, each containing a solitary pendulous seed conforming to the cavity. The testa is membranous, surrounding a copious fleshy endosperm, in which the minute embryo is embedded close to the superior hilum. The embryo is straight. The common Holly (Ilex Aquifolium) is a good type. The fruit consists of four pyrenes, and is small, as in all other species of the Order. The embryo is globose or obovoid, with the cotyledons about equal to the blunt radicle. The funicle forms a little cap surmounting the upper end.

Ilex Aquifolium, *L.* (fig. 240).

Primary root long, tapering downwards, colourless, with a few lateral rootlets.

Hypocotyl woody, erect, terete, glabrous, colourless at the base and green upwards, 3·8 cm. long.

Cotyledons ovate, obtuse, entire, coriaceous, glabrous, deep green, shortly petiolate; petiole about 1 mm. long; lamina 13 mm. long, 6 mm. broad.

Stem woody, erect, terete or slightly angled from the decurrent nature of the petioles, glabrous, green; 1st internode 3 mm. long; 2nd 1 mm.; 3rd and 4th, both belonging to a second year's growth, each 1 mm. long; 5th 4 mm.; 6th 3·5 mm.

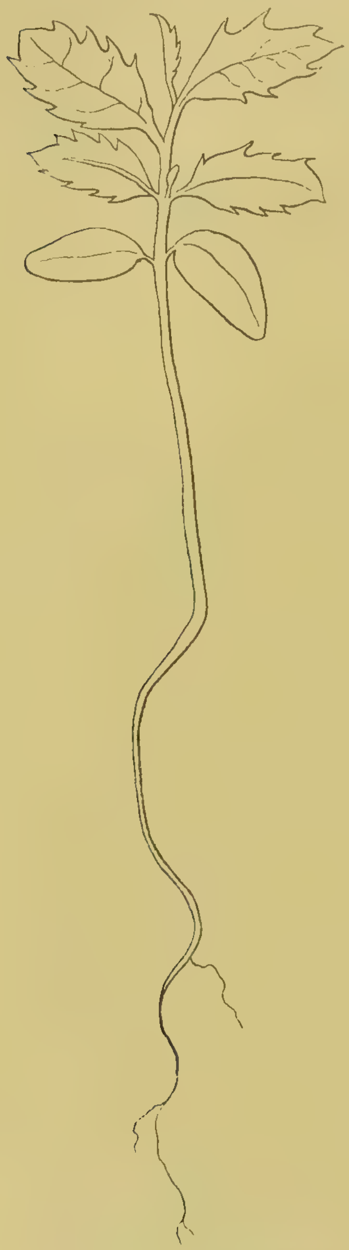

Fig. 240.—*Ilex Aquifolium.*
Nat. size.

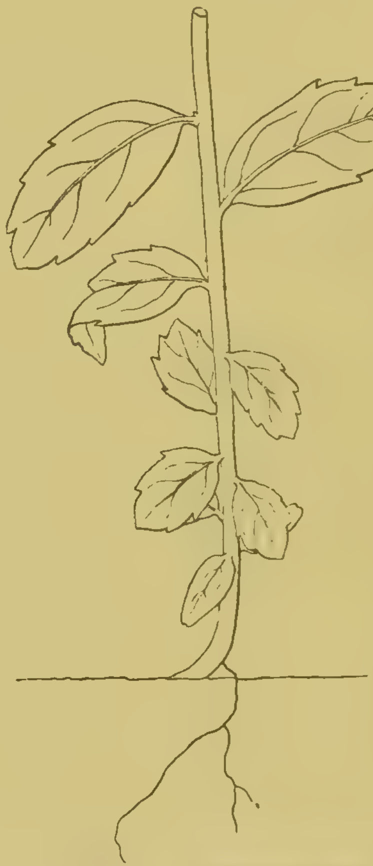

Fig. 241.—*Ilex myrtifolia.*
Nat. size.

Leaves simple, cauline, alternate, stipulate, petiolate, evergreen, coriaceous, glabrous, dark green above, somewhat paler beneath; petiole short, channelled above, thickened at the margin, as are the eaves; stipules small, ovate, acute, black, deciduous (stipules are said to be absent from the Order, but in seedlings and in the young growth of the above-named species small stipule-like bodies are present as described).

No. 1. Oblong-ovate, serrate, teeth acute, spiny.

No. 2. Lanceolate-oblong, teeth similar.

End of growth of first season.

Nos. 3 and 4. Spathulate, serrulate scales.

No. 5. Broadly oblong, obtuse, cuneate at the base, serrate, teeth spiny.

No. 6. Oblong, acuminate, cuneate at the base, serrate, teeth rather distant and spiny.

Ilex myrtifolia, *Lam.* (fig. 241).

Hypocotyl woody, erect (or decumbent—accidental?), dull green, 1·3 cm. above the soil.

Cotyledons ovate, obtuse, emarginate, persistent, shortly petiolate, glabrous, deep green, alternately but obscurely penninerved; lamina 7–9 mm. long, 3–4·5 mm. broad; the cotyledons of some of the seedlings are so narrow as to be oblong, otherwise they do not differ from the type; petiole flattened or slightly grooved above, 1·25–2·25 mm. long.

Stem woody, erect, terete, dull green, minutely pubescent; 1st internode 4 mm. long; 2nd 2 mm.; 3rd 3 mm.; 4th 4 mm.; 5th 5·25 mm.; 6th and 7th each 8 mm.; 8th 9 mm.; 9th 1·2 cm.; 10th 1·5 cm.

Leaves obscurely, alternately penninerved, with the midrib and primary veins somewhat of a milky-white, paler beneath; petioles very short, channelled above; stipules small, subulate, acute, black, deciduous, or rather caducous.

Nos. 1–5 inclusive. Oval, obtuse, apiculate, with a few acute serratures on each side.

Nos. 6–10 inclusive. Oblong, obtuse, apiculate, distantly and acutely serrate on the upper half.

CELASTRINEÆ.

Benth. et Hook. *Gen. Pl.* i. 357.

Fruit and Seed.—The ovary is two- to five-, very frequently four-celled as in many species of Euonymus, although this is not constant even on the same tree. One-celled ovaries are exceptional, but occur in Llavea, Glossopetalum, and Cathastrum.

The ovules generally number two in each loculus, ascending from the base of an axile placenta, anatropous, with a ventral raphe and an inferior micropyle. In other cases they vary with one to many ascending ovules, while another type has pendulous ovules with a dorsal raphe and superior micropyle. Solitary erect ovules occur in Hartogia, Ptelidium, Myginda, Fraunhofera, Schæfferia, and Caryospermum. From four to six or more ovules occur in a number of genera, including Lophopetalum, Cathastrum, Kokoona, Alzatea, Putterlickia, Denhamia, Wimmeria, and Goupia. The number varies considerably in different species of Euonymus, although two are most common. In Cassine the solitary ovule is pendulous from the top of the placenta. The fruit is capsular (more or less winged in Euonymus) or baccate, drupaceous, or samaroid and indehiscent with one-seeded cells. The testa is crustaceous, membranous, fleshy, or spongy, and in Perrottetia it is many-ribbed, with a moderately prominent raphe and more or less covered with a large cap- or boat-shaped arilloid funicle, or sometimes it is winged, as in Kokoona, Alzatea, and Hippocratea. The seeds of many of the genera, including Caryospermum, Schæfferia, Mortonia, Tripterygium, Elæodendron, and some species of Myginda, are not furnished with an aril. The endosperm is generally copious and fleshy. The embryo is usually very large, flat, and straight, often nearly equal to the endosperm in length and breadth. Sometimes it is linear and axile, and in Perrottetia it is minute and basal. An exceptional case occurs in Euonymus fimbriatus, which has more or less undulated or twisted cotyledons, and a curved radicle. In some genera the embryo is green. The cotyledons are mostly flat and foliaceous; and the radicle is generally inferior with the exceptions mentioned in which the ovules and seeds are pendulous.

Euonymus europæus (fig. 242) may be given as a good type of the Order. Euonymus latifolius has larger seeds and a relatively broader embryo. To this type belongs E. fimbriatus. Both have pendulous ovules.

Maytenus boaria agrees with Euonymus europæus in the insertion and direction of its ovules, but the seeds are oblong or oval; and the coty edons are oblong, rounded at both ends, and trinerved.

Seedlings.—The seedlings observed were all similar in habit and agree in all main particulars, having aerial, foliaceous, rather persistent cotyledons alternately penninerved and reticulate with incurved veins. In Euonymus europæus (fig. 243) they are entire; in Maytenus boaria (fig. 244) broadly oblong, blunt, shortly petiolate, and emarginate. They are also emarginate in Celastrus paniculatus, in which they do not otherwise materially differ from those of Euonymus europæus. The leaves of the seedlings in all the three cases are very similar to those of the adult plant. The stipules of the primary leaves are more evident in Celastrus paniculatus than in the other cases where they seem to be absent.

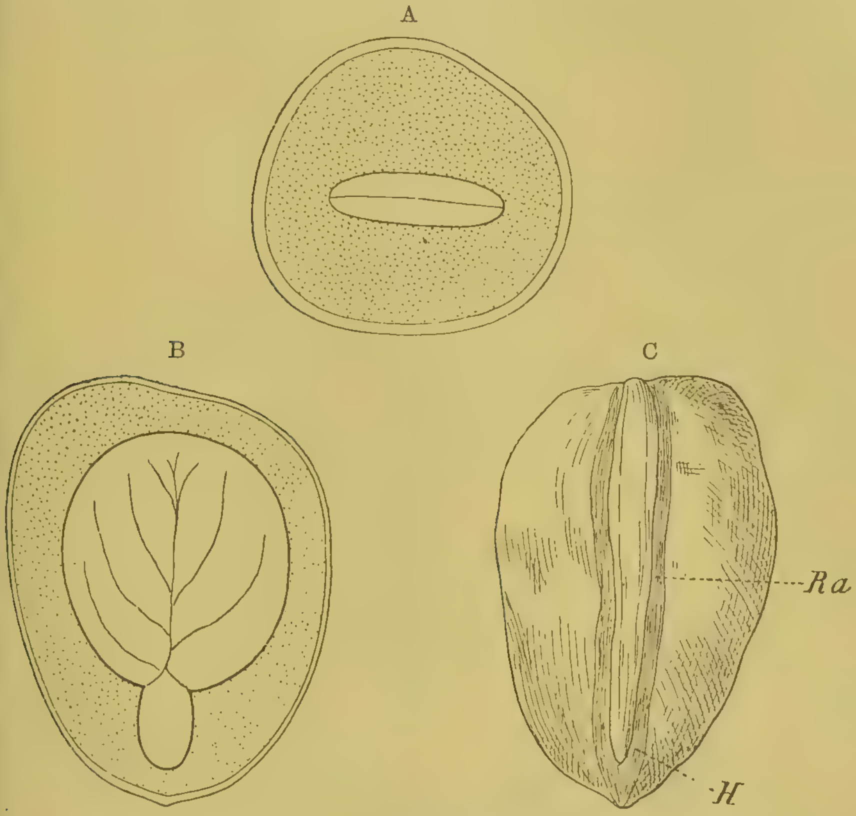

Fig. 242.—*Euonymus europæus.*
A, vertical section of seed, × 8. B, transverse section of seed, × 8 (from below middle). C, ventral aspect of seed, × 8: *H*, hilum; *Ra*, raphe.

Euonymus europæus, *L.* (fig. 242).

Pistil syncarpous, superior; ovary of four to five carpels, four- to five-, usually four-celled, with two collateral ovules in each cell;

ovules erect, anatropous, surrounded at the base by a funicular aril, cupular at first, but after fertilisation growing up and entirely surrounding the seed.

Fruit a capsule four- to five-celled, two- to five-seeded, as one of the ovules, sometimes both, is always abortive, four- to five-lobed, subturbinate, glabrous, green, becoming red as it matures, dehiscing loculicidally.

Seed obovoid, slightly compressed laterally, smooth, white and shining, closely and entirely invested with a scarlet, slightly wrinkled, funicular aril, which is attached to the oblong-linear hilum stretching along nearly the whole side of the seed to the inner angle of the cell; raphe pale yellow, continued from the hilum along the broad upper end of the seed to the chalaza seated at the top of the dorsal aspect. Seed albuminous.

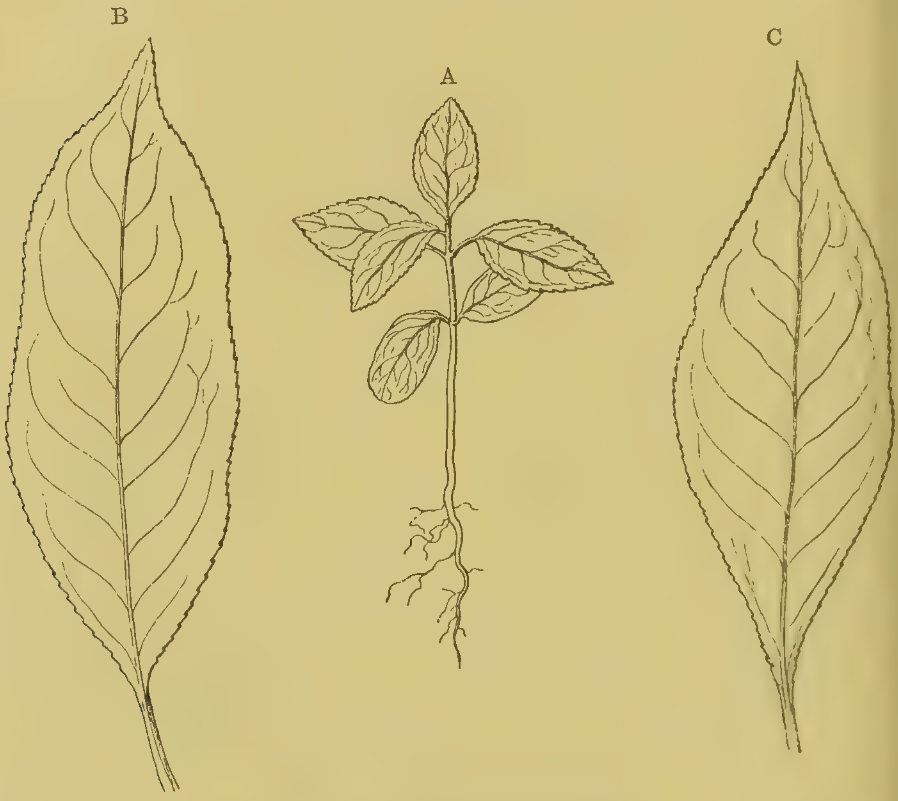

FIG. 243.—*Euonymus europæus.*

A, seedling. Half nat. size. B and C, ultimate leaves, showing two shapes.

Endosperm abundant, fleshy, firm, and white, entirely surrounding the embryo.

Embryo straight, flat, central, pale green, extending from the micropyle to within ·25 mm. of the apex of the endosperm; cotyledons foliaceous, ovate or oblong-ovate, obtuse, flat, applied to each other face to face, pale green, 4·25 mm. long, 3 mm. broad; radicle cylindrical, obtuse, 1·25–1·5 mm. long.

Seedling (fig. 243).

Primary root tapering, flexuous, giving off flexuous lateral rootlets.

Hypocotyl woody, erect, terete, glabrous, deep green, with scattered white points and short lines, about 3·8 cm. long.

Cotyledons large, foliaceous, oval-oblong, rounded at the end, alternately penninerved and reticulate, petiolate, glabrous, deep green above, pale beneath, coriaceous, rather persistent; lamina 2·1 cm. long, 1·3 cm. broad; petiole grooved above, 2·5 mm. long.

Stem woody, erect, subangled, deep green, glabrous, marked with white spots (lenticels); 1st internode 1·5 cm. long; 2nd 3·5 mm.

Leaves simple, serrulate, cauline, opposite, stipulate, petiolate, glabrous, irregularly penninerved, reticulate, deep green above, paler beneath; petioles semiterete, grooved above; stipules very small, lacerated, brownish.

1st pair lanceolate-elliptic, acute, irregularly serrulate.

2nd pair similar but smaller.

Ultimate leaves ovate-oblong or oblong, suddenly narrowed at both ends, or lanceolate-elliptic, tapering to both ends and acute, slightly irregularly crenate-serrulate, glabrous, deep green above, paler beneath.

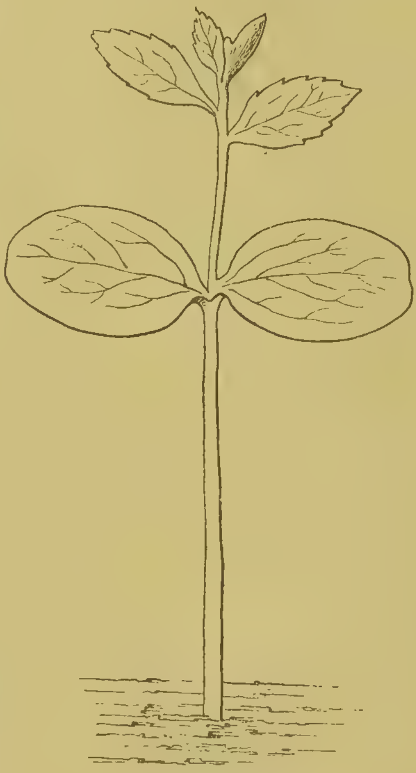

FIG. 244.
Maytenus boaria.
Nat. size.

Celastrus paniculatus, *Willd.*

Hypocotyl woody, erect, terete, densely pubescent, soon becoming brown, 1·5 cm. above the soil.

Cotyledons foliaceous, oblong, obtuse, more or less distinctly emarginate, petiolate, coriaceous, obscurely penninerved with alternate, ascending nerves, glabrous, green above, much paler, almost yellowish, beneath; lamina 2·6 cm. long, 1·5 cm. broad; petiole grooved above, pubescent on the back, 2·5 mm. long.

Stem woody, erect, terete, much kneed and flexuous in a zigzag manner, densely pubescent, pale green, soon becoming brown; 1st internode 5 mm. long; 2nd 6·75 mm.; 3rd 1·2 cm.; 4th 1·7 cm.; 5th 2·15 cm.; 6th 3 cm.; 7th 2·65 cm.

Leaves simple, cauline, alternate, stipulate, petiolate, deep green and glabrous above, paler and pubescent beneath, alternately and incurvedly penninerved, reticulate, serrate, the serratures with incurved glandular or mucronate tips; stipules small, triangular, serrate or lacerated, soon becoming brown, caducous; petioles short, channelled above, rounded on the back, pubescent.

Nos. 1 and 2. Small, elliptic, subacuminate, obtuse, apiculate.

Nos. 3–6 inclusive. Gradually and successively larger, elliptic, acuminate, obtuse, tapering almost equally to both ends, apiculate.

Maytenus boaria, *Molin.* (fig. 244).

Hypocotyl erect, terete, glabrous, 3–6 cm. long, reddish.

Cotyledons oval, obtuse, emarginate, shortly petiolate, coriaceous, 1·5–2 cm. long, glabrous, dark green, reticulate, like the first leaves.

Stem herbaceous, erect, square, rough with minute hairs; 1st internode 4–10 mm. long; 2nd and succeeding ones 2–4 mm.

First leaves simple, cauline, alternate, shortly petiolate, oval, dentate or slightly serrate, acute, glabrous, bright green, somewhat paler beneath; midrib with numerous branched veinlets.

RHAMNEÆ.

Benth. et Hook. *Gen. Pl.* i. 371.

Fruit and Seed.—The ovary is usually three-celled, but two to four cells also occur. The ovules are solitary, erect, and anatropous. Exceptions occur in Karwinskia, where there are two ovules in each cell, and the same thing happens in Condalia when two cells of the ovary become confluent in one. The raphe is dorsal or rarely lateral, and the micropyle inferior. The fruit is superior or more or less submerged in the receptacle, and when mature is three-, rarely one- to four-celled, and capsular, drupaceous, or separating more or less into cocci with a woody endocarp opening at the top. The seeds are ovoid or more or less flattened, sometimes arillate at the base. The testa is loose and membranous, or crustaceous or leathery. Endosperm is nearly always present, and fleshy. The embryo is large and straight, with flat, rarely curved or bent cotyledons, as in Rhamnus davuricus; and the inferior radicle is short. Striking exceptions in the Order occur in Ventilago and Smythea, which have a one-celled, one-seeded fruit, and exalbuminous seeds. Those of Ventilago are globose, and the cotyledons are thick and fleshy; but the seeds of Smythea are more flattened. The fruit of Ventilago is produced into a long wing.

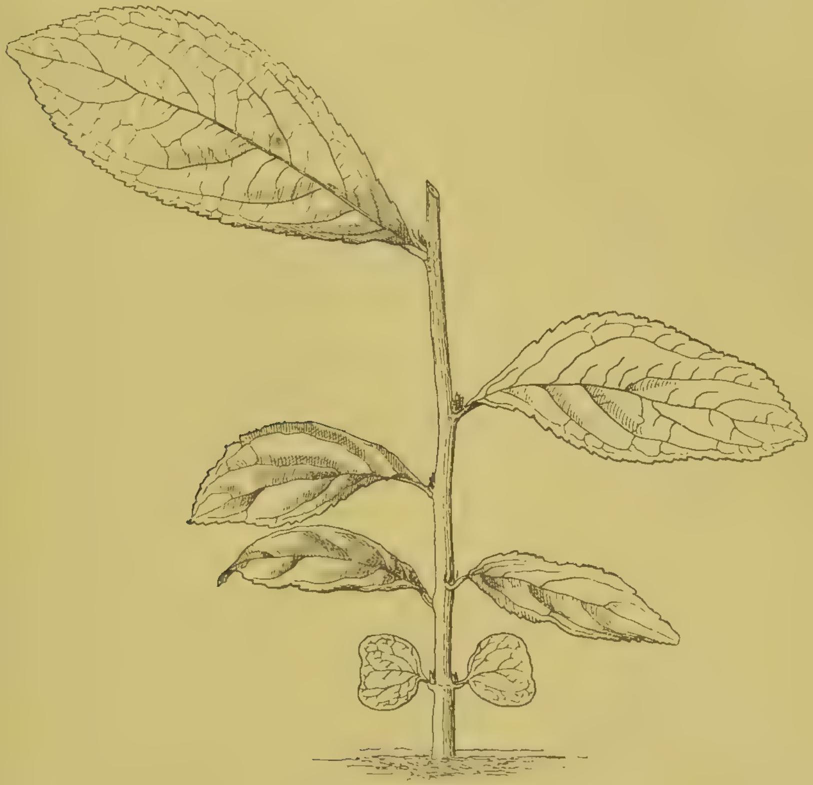

FIG. 245.—*Rhamnus davuricus.* Half nat. size.

Seedlings.—There are several types of seedlings in this Order judging from the variation amongst the seeds and their contained embryos, but they do not often come under observation in this country. Rhamnus davuricus (fig. 245) may be given as one type having aerial foliaceous cotyledons. The broad, shallow sinus at their apices seems to be due to the form of the seed and the way they are bent in conformity with it. Colletia cornuta (fig. 246) differs chiefly in the cotyledons being suborbicular and rounded at the apex.

Rhamnus davuricus, *Pall.* (fig. 245).

Hypocotyl erect, terete, rather short, soon becoming brown and woody, 12–18 mm. above the soil.

Cotyledons broader than long, almost obreniform, with a broad shallow apical sinus, suddenly cuneate at the base, five-nerved, the middle nerve bifurcate some distance below the apex, and the lateral ones much branched laterally and incurved at the apex, where they unite with the middle one, enclosing an obcordate space, the basal ones short and slender, uniting upwards with the lateral branches of the last two, glabrous, much reticulated, as seen when examined by transmitted light, shining on both surfaces, deep green above, paler beneath; lamina 10–12 mm. long, 14–16 mm. wide; petiole semiterete, flattened above, 3–4 mm. long.

Stem erect, terete, glabrous, green, soon becoming brown and striated or reticulated by splitting of the bark, woody; 1st internode about 15–16 mm. long; 2nd 4–6 mm.; 3rd 18–20 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, alternately incurvinerved, subcoriaceous, shining on both surfaces, deep green above, paler beneath, and closely reticulated, glabrous, or glandular-pubescent at the margin when young; petiole short, semiterete, flattened above; stipules slender, subulate, acuminate, pale green, seated on the junction of petiole and stem, soon becoming brown, deciduous.

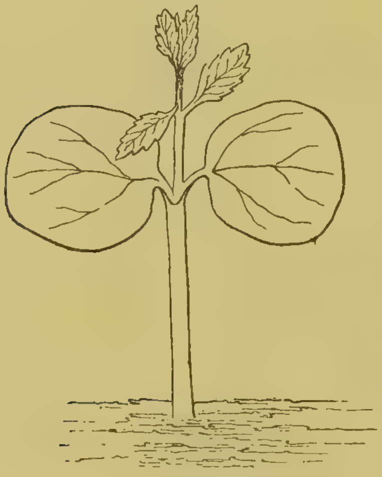
Fig. 246.—*Colletia cornuta*, × 2.

Nos. 1 and 2. Oblong-lanceolate, shallowly and distantly serrate with intermediate minute serratures or setæ.

Nos. 3 and 4. Oblong, otherwise similar, but larger.

Nos. 5-9. Oblanceolate-oblong, acuminate, tapering at the base.

Colletia cornuta (fig. 246).

Hypocotyl erect, terete, glabrous, 10–14 mm. long, green, almost colourless near the soil.

Cotyledons subrotund or oval, obtuse, entire, sometimes slightly cordate at the base, coriaceous, shortly petiolate, glabrous, dark green, pinnatinerved, the lower veins much longer than the others.

Stem erect, terete, glabrous, herbaceous at first; 1st internode 3–6 mm. long, 2nd shorter.

First leaves simple, opposite, cauline, lanceolate, acute, serrate, petiolate, stipulate, glabrous, light green, pinnatinerved.

AMPELIDEÆ.

Benth. et Hook. *Gen. Pl.* i. 386.

The ovary here is also more or less sunk in the receptacle, and consists of two to six carpels united so as to form as many cells. In the genus Vitis, which includes by far the largest number of species, the ovary is mostly two-, rarely three- or four-celled. The ovules are geminate, collateral, ascending, and anatropous in Vitis and Pterisanthes, where the ovary is most frequently bilocular; but in Leea, where the ovary is from three- to six-celled, the ovules are solitary and erect. The raphe is ventral and the micropyle inferior. The fruit is always baccate with from one to six cells according to the genus, or it may become one-celled by the destruction of the septa during ripening; each cell contains one or two seeds. The latter are always solitary in the loculi of Leea. The outer coat of the seed is bony, the inner one membranous, and both are often pushed into the endosperm, making it ruminate. In Vitis vinifera, there are two longitudinal furrows or indentations of this kind on one side of the seed with a corresponding ridge between them. The embryo is minute with oval cotyledons, and lies embedded in the cartilaginous endosperm close to the hilum. The seeds of Leea have a more decidedly ruminate albumen, and the straight or slightly curved embryo although small has subfoliaceous cotyledons.

The cotyledons are ovate or subcordate, obtuse or acute, and five-nerved. The middle pair of nerves does not, however, always spring from the base of the lamina, but sometimes at a greater or less distance above it. Vitis cebennensis (fig. 248) may be given as a good type of those with short-petioled cotyledons. V. cebennensis and V. Cynthiana agree both in the cotyledons and the primary leaves. The first one is cordate and coarsely dentate-serrate, the second subtrifid. The first leaf of V. Cynthiana is sometimes at least as far advanced as the second in other cases. A very distinct type is met with in V. hypoglauca (fig. 247), where the hypocotyl remains undeveloped and the broadly cordate, obtuse cotyledons are carried up on very long petioles. The first leaf is a small scale.

Parthenocissus tricuspidata is probably a species of Vitis, as its cotyledons agree very fairly with those of V. cebennensis. The first leaf is tripartite, with cuneate, serrated, hairy segments.

Parthenocissus tricuspidata, *Planch.*

Hypocotyl erect, terete, glabrous, 2–2·5 cm. long, red.

Cotyledons almost triangular, with rounded edges, obtuse, entire, petiolate, glabrous, green, pinnatinerved, with the nerves near the base more prominent; petioles 1·5–2 cm. long, channelled on the upper side.

Stem erect, herbaceous, ultimately woody, red; 1st internode 1–1·5 mm. long.

First leaves simple, digitate, cauline, alternate, petiolate, stipulate, trifoliolate, trinerved; leaflets lanceolate, acute, coarsely serrate, ciliate, covered with short stiffish hairs, green with a reddish tinge, pinnatinerved; petioles long, reddish, channelled on the upper side, slightly hairy; stipules membranous, reddish, oblong, entire.

Vitis hypoglauca, *F. Muell.* (fig. 247).

Hypocotyl short and subterranean, terete, tapering downwards.

Cotyledons large, unequal, cordate or rotund-cordate, obtuse, strongly trinerved with two lateral, shorter ones at the base, reticulate, petiolate, glabrous, shining on both surfaces, deep green above, paler or subglaucous beneath; lamina of the larger one 2·9–3·9 cm. long, 2·6–3·1 cm. wide; lamina of the smaller one 2·8–3·4 cm. long, 2·4–2·9 cm. wide; petioles long, semiterete, shallowly grooved above, glabrous, colourless or pinkish, 6–8·5 cm. long, often slightly unequal, with the larger one having the longest petiole by 3–7 mm.

Stem erect at first, terete, slender, glabrous, pale green, ultimately climbing and woody, zigzag or flexuose at the nodes; 1st internode 1–9 mm. long; 2nd 7–31 mm. long.

Leaves simple, cauline, alternate, stipulate, petiolate, three- to five-nerved at the base, strongly alternately nerved upwards, reticulate, shining on both surfaces, at least when young, deep green above, paler or glaucous beneath, glabrous; stipules half-ovate, membranous colourless, small; petioles semiterete, channelled above, tapering slightly upwards, glabrous, pale green or stained with red.

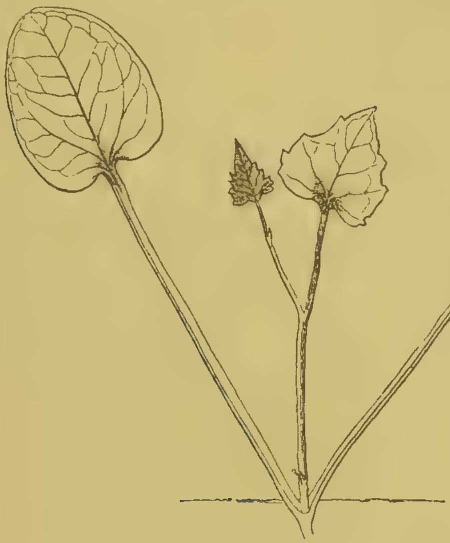

FIG. 247.—*Vitis hypoglauca.* Half nat. size.

No. 1. (following a short internode). Very small or minute, lanceolate, acute, entire, or one- to two-toothed at the sides, much reduced and scale-like.

No. 2. Triangular acute, cordate or almost truncate and five-nerved at the base, and alternately nerved upwards, irregularly dentate with rather cuspidate, acute teeth.

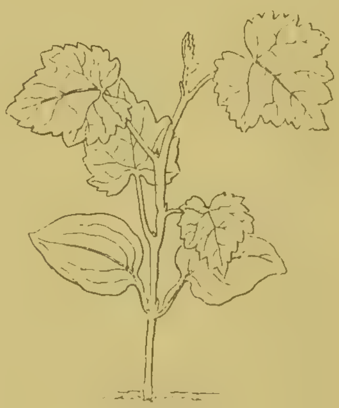

FIG. 248.—*Vitis cebennensis.* Half nat. size.

Vitis cebennensis, *Jord.* (fig. 248).

Hypocotyl suffrutescent, erect, terete, soon becoming brown, glabrous, 1–2 cm. long.

Cotyledons ovate, entire, subacuminate, glabrous, five-nerved, nerves incurved, 2·35 cm. long, 1·65 cm. broad; petiole deeply grooved above, suberect, 8 mm. long.

Stem erect at first, afterwards climbing, suffrutescent, pale green suffused with red when young, glabrous, flexuose, thickened at the nodes, succulent when young; 1st internode 1·35 cm. long; 2nd 7 mm.; 3rd 9 mm.; 4th 1·5 cm.

Leaves palmately five-nerved, glabrous except for the minutely ciliate margin, subrugose; petioles subterete, reddish; stipules ovate, subacute, serrulate at the margin, hyaline, deciduous, membranous.

No. 1. Cordate, subacuminate, with large mucronate teeth.

No. 2. Cordate, subtrilobate, otherwise like No. 1.

No. 3. Broadly cordate, palmately five-lobulate.

No. 4. Similar to the last.

Ultimate leaves broadly cordate, mucronate, palmately five-nerved and -lobulate, serrate-dentate with mucronate serratures, pubescent on the principal nerves on both surfaces; petiole pubescent, terete, striate, crimson, as are the principal nerves.

SAPINDACEÆ.

Benth. et Hook. *Gen. Pl.* i. 388.

Fruit and Seed.—The carpels vary from one to four, but three is the most common number. There are usually two in the species of Acer and Negundo, although three occasionally occur. In Dodonæa there are five or six. Dobinea is a remarkable exception, inasmuch as the ovary consists of a single carpel with a solitary erect ovule. In other cases the carpels are united to form an ovary of many cells with axile placentas, or the ovary may be deeply lobed, sometimes divided to the base into as many lobes as carpels, arranged excentrically around a gynobasic style, as occurs in some Ochnaceæ and Phytolaccaceæ. The ovules are one or two, rarely more, in each cell, anatropous, campylotropous, or amphitropous, attached to an axile placenta, and ascending with a ventral raphe and inferior micropyle. They are very rarely horizontal and numerous, or inverted. The fruit contains as many cells as there were carpels in the ovary, but is sometimes one-celled by abortion, and in Dobinea is always one-celled. When mature it forms a woody, coriaceous, or membranous capsule dehiscing in various ways, or is indehiscent. In other cases it is baccate or drupaceous, undivided or lobed, or consists of two or three samaras as in Acer and Negundo. The fruit of Dobinea is an achene. The seed is globose, or laterally compressed, sometimes arillate; exalbuminous in Sapindeæ, Acerineæ, and Dodonææ; and albuminous in Melianthea and Staphyleæ. The testa is woody, crustaceous, or membranous. The embryo is generally very large and flat, or more often spirally or circinately coiled or conduplicate, transversely biplicate, wrinkled or wavy, with green or yellow foliaceous cotyledons, or the cotyledons are thick and fleshy, sometimes conferruminate, and occasionally unequal. The radicle is short and inferior, sometimes elongated and straight, or curved upwards, or ascending towards the micropyle.

The leading types of the Order may be roughly classified by the form and characters of their fruits. Capsular, inflated, or bladdery fruits with exalbuminous seeds occur in Cardiospermum, Valenzuelia, Kœlreuteria, and Aitonia. The fruits of Erythrophysa differ in being indehiscent. The seeds of Cardiospermum Halicacabum (fig. 249) are perfectly globular, with a large reniform hilum and a transversely twice folded embryo completely filling them. Staphylea pinnata, having bladdery capsules, and globose or obovoid, albuminous seeds and a straight embryo, may be noted as a striking contrast to the above.

Spiny capsular fruits occur in Castanella and Æsculus, excluding the species belonging to the old genus Pavia. The fruit of Æsculus Hippocastanum is globose, larger than a pigeon's egg, densely covered with strong spiny emergences and dehiscing loculicidally. Each of the three cells is two-ovuled (one ovule being erect and one pendulous). Either one or the other may get fertilised; and each cell matures one seed only. Sometimes only one ovule gets fertilised in the whole ovary, and the cell containing it grows at the expense of the others, which remain small. The seed is large, depresso-globose, or variously flattened by compression, and its shining chestnut-brown testa is thick and leathery. The embryo occupies the whole of the interior, and has thick, conferruminate cotyledons, separable with difficulty when mature. The latter are petiolate; the two-leaved plumule is well developed, and the large conical radicle lies in a separate cavity in the thick testa. Spiny indehiscent fruits consisting of one to three globose, free or connate cocci occur in some species of Nephelium, and N. Litchi, having a crustaceous, brittle, tuberculated pericarp and a pulpy, edible aril, is often met with in British fruit markets. The embryo is fleshy, and the cotyledons plano-convex.

Fleshy indehiscent fruits are met with in Sapindus and others, while those of Spanoghea are fleshy, but burst open transversely. Those of Melicocca, Lecaniodiscus, and Lepisanthes are drupaceous and indehiscent. The fruits of Euphoria and Schmidelia break up into indehiscent cocci, while the cocci of Diplopeltis are dehiscent. Triangled and trilobed fruits are very frequent, but those of Bridgesia and Paullinia are three-winged.

Samaroid fruits are not unusual, and, although not typical of the Order, are frequent and important. Bridgesia, Urvillea, Toulicia, Serjania, Thouinia, and Atalaya have fruits consisting of three samaras, while those of Acer and Negundo have only two. With exception of Thouinia, all are indehiscent.

The species of Acer[1] may be grouped into five or six very distinct types according to the form of the fruit, seed, and embryo, but more particularly of the latter. The ovules are campylotropous in all cases, with the micropyle inferior, except in A. circinatum, where it is variable, ascending or horizontal, with the raphe ventral, and ascending more or less along the upper edge or surface.

The first type may be represented by A. Pseudo-Platanus. The seed-vessel is tumid on both surfaces, and the seed ovoid, slightly compressed laterally. The embryo commences by coiling round the circumference of the seed, but the cotyledons finally become transversely twice folded with their backs to the placenta and the incumbent radicle in the lower part of the seed. In rare cases the cotyledons become circinately coiled with their tips in the centre of the coil.

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[1] See an interesting memoir on this group by Pax, *Engler's Bot. Jahrb.* 1885.

Other species agreeing with this type are A. monspessulanum, A. opulifolium, A. neapolitanum and A. obtusatum. The embryo is sometimes more folded in large seeds of the same species.

A. macrophyllum may be given as another type. The seed-vessel is rather tumid and densely covered with bristly or spiny spreading hairs. The interior of the seed is furnished with an irregularly conical outgrowth of the inner coat from the region of the hilum, and although the embryo originates in the same way as that of A. Pseudo-Platanus, its growth is obstructed by the process above mentioned, around which it coils, with the edges and not the backs of the cotyledons to the placenta. The cotyledons are circinately coiled or imperfectly biplicate transversely. A. insigne behaves in the same way, but the cotyledons are more decidedly twice folded transversely, and the outgrowth from the region of the hilum is much smaller.

A third type is represented by A. pennsylvanicum. The seed-vessel is inflated or gibbous on one side, and concave on the other, the seed conforming to this peculiarity. The embryo originates in the same way as that of A. Pseudo-Platanus, but, owing to the thinness or flattening of the seed-vessel and seed, the cotyledons during their development become twisted round into a vertical position with their tips close to the hilum. The cotyledons are generally flat, but sometimes become folded at the tip. A. montanum, A. tataricum, and A. hircanum agree with this type, but the cotyledons generally become more or less undulated longitudinally owing to the seed-vessel and seed being more deeply concave. They are even sometimes longitudinally plicate and more or less folded at the tip.

A fourth type is seen in A. campestre. This agrees in general particulars with A. pennsylvanicum; but the embryo is larger and undergoes a greater amount of longitudinal and oblique folding, so that in transverse section a number of folds of the cotyledons are cut through. The seed-vessel is much compressed laterally, but not, however, concave on either side. A. campestre, A. austriacum, A. platanoides, and A. Lobelii agree pretty closely with this type, except that the last-named undergoes a considerable amount of longitudinal folding or plaiting.

A. dasycarpum seems to constitute a fifth type, but only dried herbarium specimens were examined. The seed-vessel is laterally flattened, with the seed conforming to the interior. The embryo originates like all the foregoing, and during its development it becomes twisted round, so that the cotyledons place themselves in the broad plane of the seed with their edges vertical; but they are flat, as shown in transverse section, and often oblique or not exactly opposite one another, or the tip is, sometimes at least, again reversed from the hilum towards the end of the seed away from the placenta.

The sixth type is shown in A. circinatum. The seed-vessel is tumid, not indented, and the oblong seed conforms to the interior. The curved portion of the seed containing the radicle is inferior, or in other seeds is twisted round to the side, rising obliquely, and in some cases is lateral or in others almost or quite superior. The raphe is in this case often lateral or inferior, passing round the lower instead of the upper side of the seed. The cotyledons have their edges vertical, with their backs to the radicle (incumbent), and are more or less transversely biplicate. The folds are less regular or compact than in A. Pseudo-Platanus, owing to the greater length and different shape of the seed, which conforms to the cavity containing it.

Seedlings.—There is considerable variety in this extensive Order; but the seedlings coming under my notice may be classed into three distinct groups, namely, those where the cotyledons become aerial and more or less foliaceous, those where they are subterranean, and those where they are aerial but do not leave the testa.

The strictly aerial kinds exhibit four or more forms. The cotyledons of Cardiospermum Halicacabum (fig. 250) are small, oblong, truncate, and very caducous, which may be ascribed to their character and mode of folding in the seed. The fact of their falling early points to their losing the faculty of assimilation, acting chiefly as a store-house of reserve-material, and to a tendency to become subterranean. The first two leaves are opposite and tripartite with the middle segment again trifid. Succeeding leaves are alternate and more deeply divided; the fifth one being biternate.

The oblong or strap-shaped, sessile, five-nerved cotyledons of Acer Pseudo-Platanus (fig. 252) present quite a distinct type in the Order. Their shape and size are due to the manner of folding in the seed and the shape of the latter.

The first pair of leaves of A. Pseudo-Platanus are ovate, acuminate, and cordate at the base, near which they are doubly serrate-dentate. The cotyledons of A. campestre are shorter than those of its congener and proportionately broader. The same may be said of the first pair of leaves.

The cotyledons of Dodonæa viscosa (fig. 253) in being linear-lanceolate and one-nerved remind us very forcibly of those of Billardiera amongst the Pittosporeæ. The first three or four cuneate, trifid leaves also point in the same direction. The fifth, sixth, and seventh leaves are elliptic and nearly entire.

The broadly obovate, emarginate, five-nerved and reticulate cotyledons of Melianthus major constitute a well-marked type. The foliaceous stipules, in being intrapetiolar and connate in the upper portion, are also very striking. The first two leaves are digitately trifoliolate, and succeeding ones imparipinnate with more or less winged petioles.

The subterranean type of cotyledons is represented by Sapindus inæqualis (fig. 251). The petioles are of some considerable length, although the cotyledons do not leave the large globular seed. The first four leaves are greatly reduced and scale-like, while eight succeeding ones are lanceolate, acuminate, and quite entire. In the adult state some species of Sapindus have leaves consisting of one entire leaflet, while others are abruptly pinnate. The cotyledons of Atalaya diversifolia are also strictly subterranean. The form of the leaves is rather remarkable for this Order. The first three are lanceolate and small, succeeded by two linear-lanceolate ones, and those by at least nine others which are linear-lanceolate, very narrow, and of great length.

The third group or type of cotyledons is met with in Æsculus Hippocastanum. The large fleshy cotyledons are petiolate, but do not leave the seed; and the latter is carried some considerable height above ground during germination owing to the great length of the hypocotyl. The case is quite unusual, because in the majority of seedlings, where the cotyledons do not leave the testa, the hypocotyl remains undeveloped. The first pair of leaves is compound and digitately five-foliolate. This high development may be due to the amount of reserve in the fleshy cotyledons; and the elongation of the hypocotyl is necessary to carry the true leaves up to the light, because the primary ones are not reduced to scales, as most frequently occurs where the cotyledons are fleshy and do not leave the testa. The opposite leaves of Æsculus, Acer, and Negundo are quite unusual in the Order.

Blepharocarya involucrigera, *F. Muell.*

Hypocotyl erect, terete, glabrous, green, soon becoming woody, brown, and covered with pale brown lenticels, 1·5–2·8 cm. above the soil.

Cotyledons subovate, obtuse, falcate, somewhat unequally and shallowly cordate at the base, slightly cut away on one side and with a shallow sinus about the middle of the other, obscurely, but quite evidently alternately incurvinerved and reticulate, glabrous, deep green above, paler beneath, petiolate; lamina 1·3–1·5 cm. long, 7–8·25 mm. wide near the base; petiole slender, semiterete, channelled above, glabrous, or nearly so, slightly connate at the base in the early stages, about 1·5–2 mm. long.

Stem erect, terete, covered with a silky, adpressed, persistent pubescence, pale green, soon becoming brown, woody, and covered with small, pale brown, elevated lenticels; first twelve internodes varying from 3–8 mm. long, increasing in length upwards.

Leaves compound, imparipinnate (first seven or eight simple and entire), cauline, alternate, exstipulate, petiolate, glabrous except the petioles and petiolules, coriaceous, deep shining green above, paler beneath and shining; leaflets lanceolate, acuminate, rounded or suddenly and slightly tapering at the very base, alternately incurvinerved and reticulate with the lateral nerves slightly ascending, incurved, branched, and anastomosing near their summit with the branches ending in a colourless cartilaginous margin; petioles tapering upwards from a very stout base, which is flattened above, while upwards it becomes more slender and nearly terete, deep brownish-red, and more or less densely covered with adpressed pubescence; petiolules short, subterete, narrowly channelled above, otherwise like the petioles.

Nos. 1–7 or 8. Simple, entire, ovate-lanceolate, acuminate, obtuse, having a pulvinus at the base of the lamina, which is articulated with the petiole, proportionately broader than the leaflets of the following compound leaves.

No. 8. Uni- to tri-foliolate.

No. 9. Trifoliolate.

No. 10. Five-foliolate.

Nos. 11 and 12. Five- to seven-foliolate, and gradually larger.

Cardiospermum Halicacabum, *L.* (fig. 249).

Fruit a capsule, triangular, with globose, membranous lobes, each one-celled, one-seeded, dehiscing loculicidally.

Seed globose, deep brown, shining, glabrous, very hard; hilum broad, reniform, transverse, whitish; raphe none; chalaza very large, broad, lunate, lying along the upper side of the hilum, and indicated by a slight elevation or thickening; testa very hard, crustaceous; tegmen thin, closely adhering to the testa.

Endosperm absent.

Embryo filling the interior of the seed, transversely plaited; cotyledons cuneate-spathulate, entire, minutely auricled at the base, with a few large transverse folds to accommodate themselves to the globose seed, thick and fleshy, pale yellow. In the transverse section two segments of the cotyledons appear thicker than the central two lobes, owing to the former being cut obliquely; radicle very short, oblong-ovoid, obtusely pointed, seated in a small, shallow notch at the base of the cotyledons, and forming an impression near the tip of the back of the inner cotyledon, embedded in the testa at its tip.

Seedling (fig. 250).

Primary root vertical, with a few thin, lateral, branched, horizontal rootlets, firm, colourless.

Hypocotyl herbaceous at first, 3–4 cm. long, a little over 1 mm. thick, round, pubescent, light green.

Cotyledons sessile, about 1 cm. long, 2–3 mm. broad, thick, ligulate, truncate and broad at the apex, yellowish-green, glabrous, caducous.

Stem herbaceous, terete, 1 mm. thick; 1st internode 1·5–2 cm.

long, obtusely four-angled from the decurrent petioles, twisted, pubescent.

Leaves.—Nos. 1 and 2. Opposite, petiolate, ternatisect; petiole

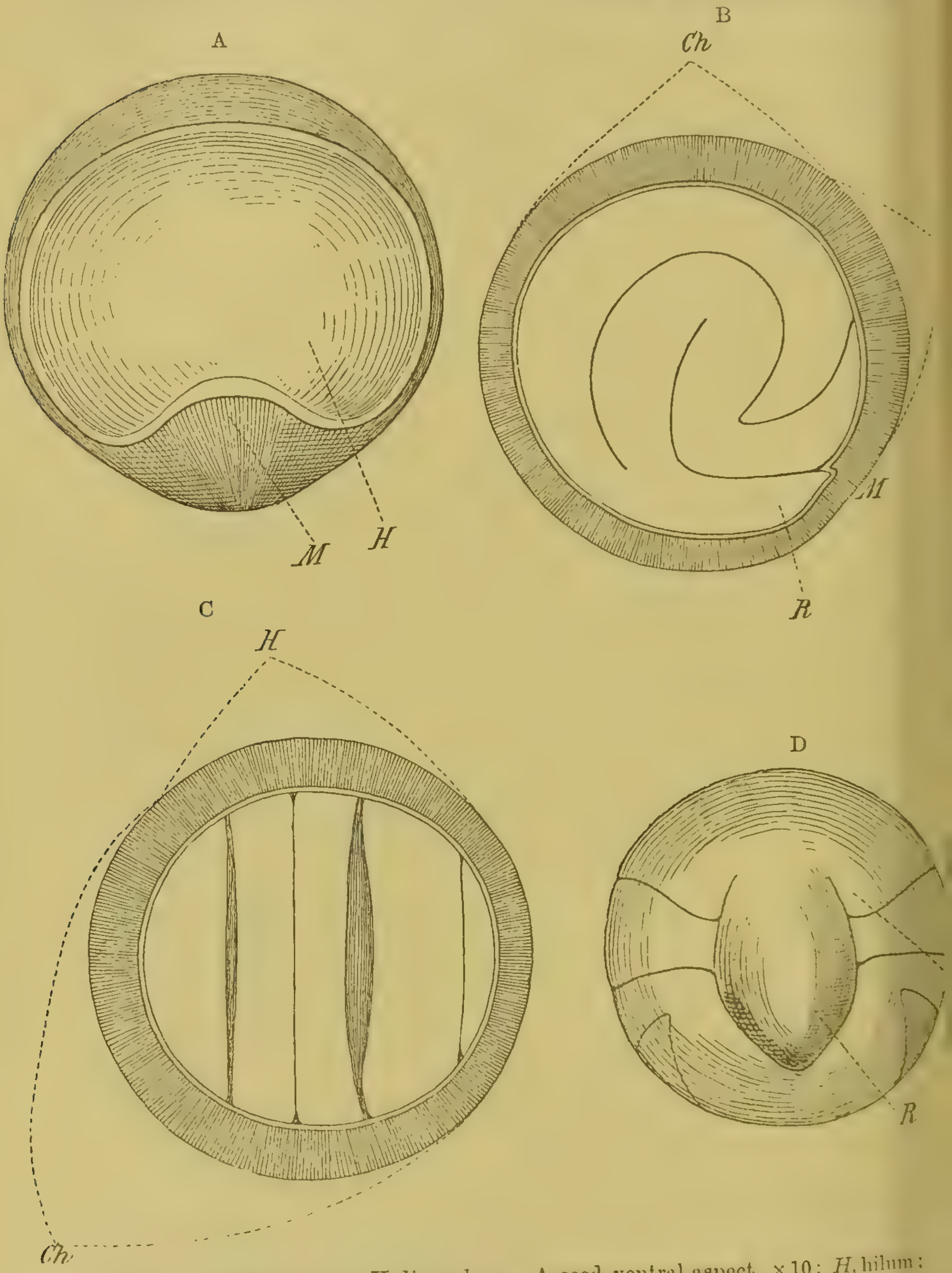

FIG 249.—*Cardiospermum Halicacabum*. A, seed, ventral aspect, × 10: *H*, hilum; *M*, micropyle. B, longitudinal section of seed, × 10: *R*, radicle; *M*, micropyle; *H*, hilum; *Ch*, chalaza. C, transverse section of seed, × 10: *H*, hilum; *Ch*, chalaza. The outer lobes seem broader, being rather obliquely cut. D, embryo removed from seed, × 10: *A*, auricle of cotyledon; *R*, radicle.

about 1·5 cm. long, 1 mm. thick, shallowly channelled, pubescent; terminal segment of lamina about 2·5 cm. long, 1·25–1·75 cm. broad, cuneate at base, trifid, with a few coarse teeth; lateral segments about 2 cm. long, ·75 cm. broad, obliquely oblong, cuneate at base, obtuse at apex, entire or obtusely serrated, or bi- or tri-fid; the common margin pubescent, and a few hairs on the nerves of the lower surface of the segments, otherwise glabrous, thin, bright green above, a little paler below.

Nos. 3 and 4. Similar, but more deeply cut, and with acuminate apices.

Nos. 5 and 6. Similar, bi-ternatisect, with rhomboid, acuminate, serrate lobes.

Leaves biternate or decomposite in the adult state, cauline, alternate (first two opposite), exstipulate, petiolate, alternately or oppositely penninerved, with ascending, branching nerves, membranous, pubescent on the margins and nerves beneath; petiole semiterete, channelled above, somewhat dilated at the base.

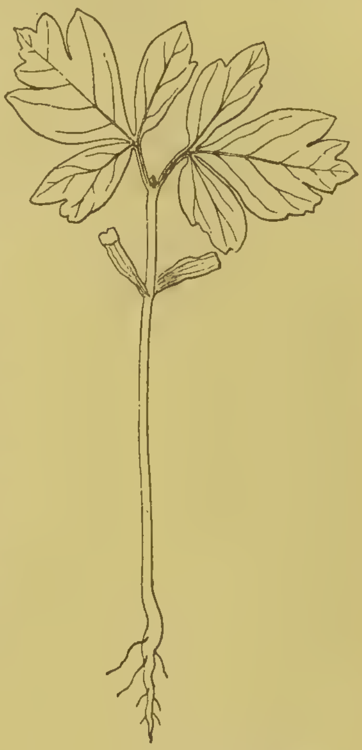
FIG. 250.
Cardiospermum Halicacabum.
Two-thirds nat. size.

Atalaya diversifolia, ? *F. Muell.*

Hypocotyl subterranean.

Cotyledons subterranean.

Stem woody, erect, terete, flexuous, leafy, pale green, pubescent; 1st internode 2·3 cm. long; 2nd ·5 mm.; 3rd undeveloped; 4th 8 mm.; 5th 2·5 mm.; 6th 4 mm.; 7th 6·75 mm.; 8th 3·5 mm.; 9th 4·75 mm.; 10th 3 mm.; 11th 3 mm.; 12th 2 mm.; 13th 3 mm.; 14th 4 mm.; 15th 3 mm.

Leaves simple, entire, cauline, alternate, exstipulate, very shortly petiolate, glabrous, alternately penninerved and reticulate, with the midrib prominent on both surfaces, thin, coriaceous, deep green above, paler beneath; petioles very short, thickened at the articulation, flattened above with a prominent midrib.

Nos. 1–3. Small, lanceolate, obtuse.

Nos. 4 and 5. Small, linear-lanceolate, subacute.

Nos. 6–8. Linear-lanceolate, acute.

Nos. 9–14. Long, linear, acute, arching.

Sapindus inæqualis, *DC.* (fig. 251).

Hypocotyl undeveloped.

Cotyledons large and fleshy, filling the seed, which they do not leave in germination; petioles thick, fleshy, colourless, semiterete, pushed out of the seed or elongated to convenience the radicle and plumule.

Stem erect, terete, green, hairy, soon becoming glabrous, ultimately woody; 1st internode 2·5 cm.; 2nd ·95 cm.; 3rd 2 cm.; 4th ·95 cm.; 5th 2·1 cm.; 6th ·55 cm.; 7th ·75 cm.

Leaves cauline, alternate, exstipulate, petiolate, irregularly and alternately penninerved with ascending nerves, thinly hairy on both sides, soon becoming glabrous above, pale green and shining above; petioles short (in the seedling), semiterete, furrowed above on each side of the midrib, slightly hairy.

Nos. 1–4. Linear-lanceolate, acute, small and scale-like.

Nos. 5–7. Lanceolate, broadest above the middle, cuspidately acute or shortly acuminate, tapering into a short petiole.

Nos. 8–11. Lanceolate, acuminate, petiolate, much larger than any of the preceding.

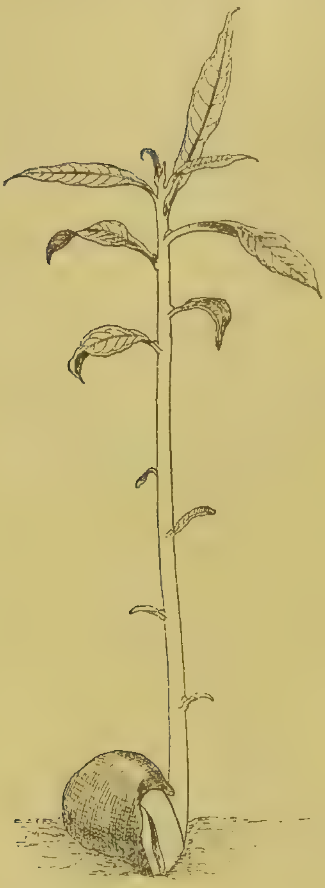

FIG. 251.—*Sapindus inæqualis.* Half nat. size.

Acer Pseudo-Platanus, *L.*

Pistil syncarpous, superior; ovary of two carpels, two-celled, each cell two-ovuled; ovules collateral or slightly superimposed, ascending, campylotropous; radicle inferior, close to the hilum. Only one ovule in a cell is habitually fertilised, generally, if not always, the upper one when they are superimposed.

Seed ovoid, slightly compressed laterally, somewhat narrowed to an obtuse point at the upper end; testa thin, ultimately membranous; hilum about the middle of the ventral aspect; micropyle inferior but pointing slightly upwards and contiguous to the hilum: chalaza very large, superior, covering nearly or quite the whole of the upper part of the seed.

Endosperm, from the earliest stages till it is wholly absorbed, thin, watery, or jelly-like. (See *Linn. Journ.* xxii. 399, fig. 133.)

Embryo originating in a short tubular prolongation near the micropyle, and at first straight, with an extremely short, turbinate radicle, and ovate, obtuse, closely adpressed cotyledons. It then continues to grow along the lower side of the seed, close to the testa; and, the outline of the seed being curved, the embryo gradually curves also. The cotyledons are now lanceolate or oblong-lanceolate. When the cotyledons have reached the upper and narrow end of the seed they curve rather suddenly downwards. This is continued until the tips reach the radicle, leaving the front and upper part of the seed under the chalaza empty except for the endosperm. The embryo is now a considerable size, with an elongated radicle and oblong, obtuse cotyledons. The next stage is characterised by a second curving of the cotyledons, and it depends whether the latter now curve inwards or outwards, as to the form the embryo shall ultimately assume. If they curve inwards the mature embryo will be circinate. If they now curve outwards the mature embryo will be transversely twice folded (conduplicate, 'Genera Plantarum'), and this is the commoner form.

In this case the tips of the cotyledons curve outwards and upwards to the chalaza. The embryo enlarges considerably after this, and the double portion of the cotyledons is now pushed into the centre of the seed, with the radicle on the lower side and the middle of the cotyledons on the upper side abutting against the chalaza, while the tips, still continuing to elongate, grow outward and upwards, reaching as far as the lower end of the chalaza.

In August the embryo is well formed, but the endosperm not yet all absorbed.

Seedling (fig. 252).

Primary root tapering, flexuous, rather stout, with a few lateral rootlets.

Hypocotyl 3–4 cm. long, 1·5 mm. broad (because of its being slightly compressed), glabrous, firm, reddish-brown.

Cotyledons two, often three (when two, one of them is frequently split), sessile, 3·5–5 cm. long, about 8 mm. broad, strap-shaped, obtuse, entire, obscurely trinerved, glabrous, pale green, rather persistent.

Stem soft, but soon becoming woody, erect, terete, glabrous, pale or brownish-green; 1st internode 2–3·5 cm. long; 2nd 1·5–2 cm.; 3rd 6–8 mm.

Leaves simple, cauline, opposite, rarely three at the same level and verticillate, exstipulate, petiolate, glabrous except at the very base on the under side ; petioles terete, generally slightly channelled on the upper side when young, ultimately not channelled.

1st pair ovate, acuminate, cordate, and palmately five-nerved at the base, reticulate, irregularly and obtusely serrate.

2nd pair palmately five-nerved and lobed or lobulate, irregularly and coarsely dentate-serrate ; terminal lobe triangular ovate, obtuse ; middle lobes very broad and short, obtuse ; basal lobes small or merely tooth-like and obtuse.

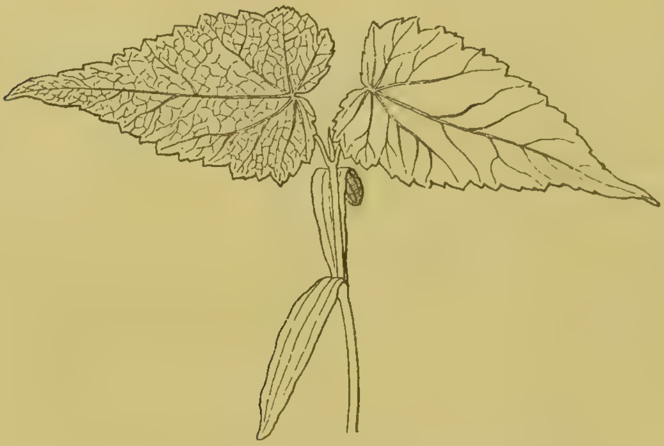

FIG. 252.—*Acer Pseudo-Platanus.* Half nat. size.

3rd pair similar.

Ultimate leaves large, palmately five-nerved and -lobed, subcordate at the base ; lobes triangular-ovate, acuminate, obtuse, rather coarsely, irregularly, and distantly serrate ; basal lobes smallest.

Acer macrophyllum, *Pursh.*

Fruit of two, rarely three samaras ; wings ascending, oblong, obtuse, asymmetrical or half-elliptic, reticulate, nearly glabrous except on the thickened portion along the lower side, which is covered with adpressed hairs or bristles ; seed-bearing portion of fruit ovoid, densely covered with rigid spreading bristles or spiny hairs, rather tumid.

Seed nearly horizontal or slightly ascending, short, deep, somewhat obovate in vertical section at right angles to the placenta, and triangular in vertical section parallel with the placenta, rather tumid and conforming to the cavity of the fruit, exalbuminous ; tegmen enormously thickened near the hilum, forming an irregularly conical process projecting into the middle of the seed.

Embryo originating in the apical, neck-like, curved portion of the seed; cotyledons ascending with their backs to the placenta as in A. Pseudo-Platanus, till they reach the thickening and enlarging process of the inner seed-coat, round which they twist across the cavity of the seed with their edges to the placenta, as do those of A. insigne, with their broad plane in consequence at right angles to the placenta and conduplicate as in A. Pseudo-Platanus; radicle rather long, terete, bluntly pointed, inferior, and slightly descending or nearly horizontal.

Acer insigne, *Boiss. et Buhse.*

The two samaras are often or always of unequal size, owing to the non-development of the ovules in one of the cells; wings ascending or suberect, obliquely or half obovate, rounded at the apex, reticulate, slightly pubescent or nearly glabrous; seed-vessel tumid, ovoid in outline.

Seed slightly ascending, ovoid, obtuse, somewhat flattened laterally from the base towards the end distant from the hilum, conforming to the cavity of the fruit; tegmen thickened in proximity to the hilum and chalaza, but the outgrowth much smaller than in A. macrophyllum.

Embryo behaving in the same way as in A. macrophyllum, but the cotyledons are more decidedly transversely biplicate.

Acer pennsylvanicum, *L.*

Fruit.—The portion of the fruit containing the seed is rather inflated or gibbous on one side and concave on the other; this concavity sometimes occurs on the same side of both halves of the fruit, or on alternate sides of them.

Seed broadly oblong in outline, more or less compressed laterally but conforming to the cavity of the ovary and therefore concave towards its indentation and convex to its gibbous side; seed-coat double; hilum on the basal end of the seed.

Embryo large, filling the cavity of the seed; cotyledons straight and plane or nearly so, but often folded back at the tip; concave in conformity with the fruit and seed; radicle about equal to the seed in length, terete, straight, or curved at its base only, the fold being chiefly in the base of the cotyledons.

A. tataricum conforms to the same type, but the cotyledons are thrown into one or two folds, owing to the greater concavity of the seed-vessel and seed.

A. hircanum also agrees, but the seed being considerably flattened and the linear-oblong cotyledons broader than its width, these are thrown into various contortions, lying in the broad plane of the seed.

Acer campestre, *L.*

Seeds suborbicular, rather broader on the attached side, much compressed laterally, and conforming to the shape of the cavity of the samara ; seed-coat double ; hilum on the basal edge.

Embryo large, filling the cavity of the seed ; cotyledons incumbent, with their backs to the placenta, originating in the narrow plane of the seed ; but as they get too large for the space, becoming twisted round so as to lie in the broad plane with their edges to the placenta ; finally getting too long for the seed, they form two large folds in the middle, and the tips are thrown back over the basal portion close to the radicle, between which and the edges of the basal portions they always lie ; radical inferior, terete, rather pointed, curved at its base, or gradually throughout its length.

Acer dasycarpum, *Ehrh.*

Seed broadly oblong, laterally flattened, conforming to the cavity of the carpel, exalbuminous ; seed-coat double ; testa moderately thick and black ; tegmen thin and membranous.

Embryo large, filling the seed, yellowish ; radicle terete, occupying the lower side of the seed ; cotyledons incumbent originally, that is with their backs to the placenta, but ultimately turning round with their edges vertical to the axis of the fruit and their tips towards the placenta ; by so doing they place themselves in the broad plane of the laterally compressed seed. After reaching the base of the seed close to the hilum they become folded back again towards the farther end, and in so doing one apical half is folded inside the other. In the specimen examined, the two cotyledons were not strictly opposite, but placed obliquely. There was, however, no plaiting or folding. Radicle filiform, straight, occupying the lower edge of the compressed seed. Petioles of the cotyledons slightly curved.

Acer circinatum, *Pursh.*

Seed oblong, obtuse at either end, tumid, conforming to the cavity of the ovary ; seed-coat double ; hilum at one end of the seed ; raphe encircling the whole basal portion of the seed ; funicle short, thick, and with a development of cortical tissue.

Embryo originating in the neck-like portion of the ovule, which is curved round against a cortical development of tissue from the funicle ; radicle terete and stout, equal to the neck of the ovule in length, obtuse, somewhat constricted where the cotyledons commence, horizontal and occupying the base of the seed, or rising obliquely, or almost superior (contrary to the usual rule), and hence lying on the upper side of the seed. Hence the cotyledons and radicle are not always in the same vertical plane.

Cotyledons usually vertical, that is, lying on their edges in the base of the seed, incumbent, following the outline of the cavity of the seed as they grow, curving round the end distant from the hilum, and then growing into the cavity of the endosperm somewhat loosely till they touch the end next the hilum, and, growth continuing, become too long for the space, and so get doubled up against their own basal portion and the infolded portion of the seed. Their apex then recurves and grows backwards away from the hilum.

The cotyledons still have their backs to the placenta, as in *A. Pseudo-Platanus*, although they are in this particular instance vertical to the axis of the pistil.

Dodonæa viscosa, *L.* (fig. 253).

Hypocotyl erect, terete, minutely and rather densely pubescent, pale green or reddish, 1·5–3 cm. above the soil.

Cotyledons linear-lanceolate, acute or subacute, entire, sessile, or appearing shortly stalked by being narrowed at the base, with a distinct midrib but no other discernible venation, horizontal, glabrous, light green above, paler beneath, 1·9–2·5 cm. long.

Stem erect, terete, flexuous, densely pubescent with upcurved and incurved hairs, and more or less densely dotted with sessile glands, pale green, becoming reddish, ultimately woody; 1st internode 2–4 mm. long; 2nd 1·5–2 mm.; 3rd 3–4·5 mm.; 4th 4–6 mm.; 5th and 6th each 5–6 mm.

Leaves simple (at least in the seedling), cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved, more or less pubescent on both surfaces, especially on the nerves, slightly scabrous on the principal nerves, light or deep green above, paler beneath and shining, often with a glaucous hue; petiole short, stout at the base and more slender upward, slightly channelled above with an

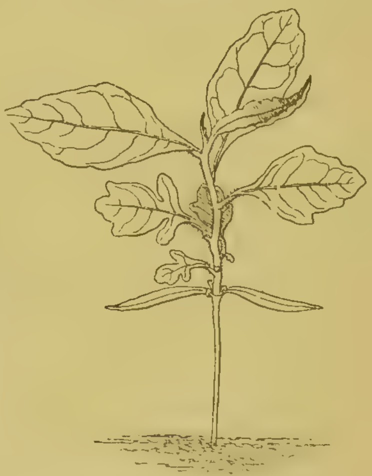

FIG. 253.—*Dodonæa viscosa.* Half nat. size.

elevated midrib, pubescent, winged upward by the decurrent lamina of the leaf.

No. 1. Cuneate, trifid or tripartite, with obtuse segments.

Nos. 2 and 3. Similar, but larger—terminal lobe largest, cuneate, and generally again more or less trifid.

No. 4. Rhomboid, obtuse, cuneate or decurrent at the base on the petiole, with two to three coarse obtuse teeth on each side.

Nos. 5–7. Rhomboid or elliptic or oblong, variable, obtuse, obtusely toothed or shallowly sinuate or entire, tapering into the petiole at the base, forming a wing to the latter.

Melianthus major, *L.*

Primary root a vertical, succulent, colourless tap-root; stout, colourless adventitious roots spring from the thickened base of the hypocotyl.

Hypocotyl about 2 cm. long, 1·5–2·5 mm. thick, terete, glabrous, brownish above ground, colourless below.

Cotyledons subsessile, nearly equal, about 2·5 cm. long and 1·75 cm. broad, obovate, cuneate at the base, emarginate with a short blunt mucro, with very distinct whitish incurved nerves on each side of the midrib, quite glabrous, thin, rather firm, bright green above, paler and shining beneath.

Stem erect, terete, glabrous, succulent, stout, pale green; 1st internode 1·2 cm. long, 3 mm. thick; 2nd internode 6 mm. long, 2 mm. thick.

Leaves cauline, compound, pinnate, alternate, stipulate, glabrous, petiolate.

No. 1. Lamina digitately trifoliolate; lateral leaflets sessile, oblong, acute, serrate, unequal on the posterior basal side, penninerved, bright green above, paler or subglaucous beneath with prominent nerves; nerves alternate or opposite; serratures acute, tipped with a yellow mucro; terminal leaflet obovate-elliptic, acutely serrate, narrowed to the base, penninerved with opposite or alternate nerves; free part of petiole terete, pale green; stipules large, foliaceous, and amplexicaul at the base, adnate to the petiole for more than half their length, then connate by their edges, leaving only their two acute tips free.

No. 2. Exactly similar; petiole similar; stipules forming a sheath to the next younger leaf and bud. In some plants the petiole of the first and second leaf has a foliaceous, decurrent wing, somewhat toothed or distantly serrate, and its uppermost part produced into a semi-triangular acuminate lobe.

No. 3. Five-foliolate; basal leaflets oblong, incise and irregularly serrate, oblique on the posterior basal side; middle pair of leaflets similar but decurrent on the petiole; terminal leaflet oblong, cuneate at the base, grossly serrate.

No. 4. Seven-foliolate.

Staphylea pinnata, *L.*

Fruit a large, inflated, membranous capsule, strongly reticulated, with a strong midrib to each carpel, glabrous, two- to three-celled with generally one large horizontal seed in each cell, dehiscing at the apex on the ventral side of the persistent styles.

Seed large, globoso-obovoid, horizontal, shining, pale brown, glabrous; testa bony, thick; tegmen thin, membranous, pale-coloured; hilum large, forming a circular depression in the outer coating of the seed; micropyle conspicuous, contiguous to the depressed hilum, and terminating a basal ridge or lobe of the seed, into which the radicle is directed; raphe lateral, forming a ridge along the side or edge of the slightly horizontally compressed seed; chalaza broad, apical.

Endosperm copious, fleshy, colourless.

Embryo large, straight, pale green, embedded in the axis of the endosperm; cotyledons broad, somewhat obliquely obovate, obtuse, shallowly auricled at the base, otherwise entire, plano-convex, falling a little short of the length and breadth of the endosperm, lying across the seed obliquely; radicle very short, globose, obtuse, or more or less flattened horizontally, pointing into the micropyle at one side of the hilum, inferior in ascending seeds but apparently always horizontal in this species like the seeds.

SABIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 413.

Fruit and Seed.—The two- to three-celled ovary contains one or two superposed or collateral ovules in each cell, which are horizontal or pendulous with a ventral raphe and an inferior micropyle. The fruit consists of one or two drupaceous, or dry, indehiscent pieces, which in the typical genus Sabia are reniform and compressed. The endocarp is bony or crustaceous, nut-like, and contains a single nut-like seed. The latter conforms to the cavity of the endocarp and is compressed or globose with a membranous or leathery testa. It is exalbuminous or contains a small quantity of endosperm adhering to the testa. The embryo is large, with rather fleshy, wavy, conduplicate, or variously twisted cotyledons, and a fleshy, descending, incurved or flexuous radicle, pointing upwards to the hilum. The latter is broad and conspicuous.

Ophiocaryon paradoxum is known as the Snake Nut, from the manner in which the embryo is coiled up in the seed resembling a snake. The cotyledons are membranous and foliaceous.

Seedlings.—The species of this Order are natives of tropical and subtropical countries north of the equator, and seedlings do not often come under observation. The cotyledons of Meliosma pungens (fig. 254) are foliaceous, aerial, and penninerved with incurved veins. They are oblong in outline and glabrous, whereas those of M. Arnottiana are oval or elliptic and ciliated at the margin. The first leaf of M. pungens is cuneate-elliptic, that of M. Arnottiana lanceolate and simple.

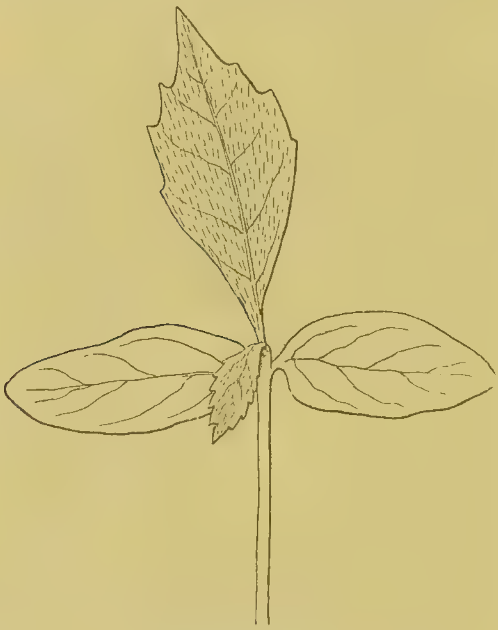

FIG. 254.—*Meliosma pungens.* Two-thirds nat. size.

Meliosma pungens, *Wall.* (fig. 254).

Hypocotyl somewhat woody, terete, 3–4 cm. long, 1·5 mm. thick, pubescent, brownish-grey.

Cotyledons unequal, subsessile, 2·5–3·5 cm. long, 1·5–2 cm. broad, oblong, obtuse, rounded at the base, penninerved, with incurving veins, reticulate, glabrous, coriaceous, dark green with brownish spots above, paler and shining beneath, rather persistent.

Stem short, like the hypocotyl, but with longer hairs. 1st internode 1 mm. long.

First leaves simple, cauline, alternate, exstipulate, petiolate, alternately penninerved, hispid or hairy above, and deep shining green, tomentose beneath; petioles short, at least in early stages of the plant.

No. 1. 3–4 cm. long, 1·5–2 cm. broad, elliptic, narrowed to both ends, sinuate-serrate, with reclined points, penninerved, thin, hispid above, tomentose on the margin and beneath, shining green.

No. 2. Ditto.

Meliosma Arnottiana, *Wight.*

Hypocotyl as in M. pungens, but minutely pubescent and greenish or slightly tinged with red.

Cotyledons oval-oblong or elliptic, acute, entire, shortly petiolate, ciliate, otherwise glabrous, light green, pinnatinerved as in the leaves.

Stem erect, terete, pubescent, herbaceous; 1st internode 2–3 mm. long.

First leaves ovate-lanceolate, acute, almost acuminate, coarsely serrate, coarsely hairy, green, pinnatinerved.

ANACARDIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 415.

Fruit and Seed.—The ovary in this Order generally consists of one carpel and is therefore one-celled; but in the tribe Spondieæ the ovary is syncarpous, consisting of two to five carpels and containing as many cells. From the occurrence sometimes of several distinct carpels in one flower, the one-celled ovaries may be considered as reduced types. This is strengthened by the fact that a three-celled ovary occurs, though rarely, in some of the species of Pistacia, where the one-celled condition is the rule. The flowers are polygamo-diœcious or unisexual, and in some of the potentially male flowers there are four or five aborted carpels or a four- to five-partite ovary in the same condition. The ovules are solitary in each ovary or in each cell of the plurilocular ovaries, and pendulous, or attached to the side walls of the carpels or suspended by a funicle arising from the base of the cell. The micropyle is inferior and the raphe dorsal or passing round one end of the horizontal seed and along the dorsal edge for some distance, as in Buchanania latifolia, where it is very thick and prominent. In Pistacia the ovule is erect, with a ventral raphe and an inferior micropyle.

The fruit is superior or partly submerged in the receptacle, one- to five-celled and nearly always drupaceous and indehiscent. The endocarp is bony, crustaceous, or leathery, and sometimes bursts open by two valves, as in Mangifera indica and Buchanania. In some of the species of Pistacia it behaves in the same way. The tissue of the fruit often contains large cavities filled with an oily or caustic juice as in Schinus Molle and Schinus terebinthifolius. A curious case occurs in Anacardium occidentale, where the receptacle becomes very large, pyriform, and fleshy, forming a pseudo-fruit, bearing at its apex the very much smaller, reniform, true fruit. The other five species, as well as those of Gluta, have also a stipitate fruit.

The seed is horizontal and lies across the receptacle, or erect, or pendulous, with frequently a swollen or umbilicate funicle.

The testa is generally if not always membranous, and is occasionally united firmly with the endocarp. Endosperm is nearly always absent, or forms a thin layer as in some species of Schinus and in Smodingium. The cotyledons are thin and plano-convex, or of great thickness and fleshy. The short radicle is straight or variously curved, pointing upwards or downwards to the micropyle.

Types with comparatively thin cotyledons are represented by Schinus Molle (fig. 259) and S. terebinthifolius (fig. 260). Their thinness is explained by the narrowness of the cavity of the endocarp and by the presence of a moderate quantity of fleshy endosperm. Thick cotyledons of peculiar form are exhibited by Buchanania latifolia (fig. 258). A stout cord-like funicle runs along the basal end and half-way round the upper edges of the cotyledons, forming a deep furrow.

Seedlings.—There are two leading types of seedlings, namely, those with aerial and those with subterranean cotyledons. The most prevalent form of cotyledons is ovate, obtuse, trinerved, shallowly sinuate on one side, otherwise entire and shortly petiolate. This is well represented by Schinus terebinthifolius (fig. 260); the cotyledons besides showing the characters above mentioned are more conspicuously reticulate than happens in many others which are more opaque.

Schinus Molle (fig. 259) and Duvaua dependens agree in all essential points. The mode of germination of the seed from the drupaceous fruit is shown in Schinus Molle. Duvaua dependens differs in the obscure venation and the cotyledons not being sinuated on one side. This shallow sinus owes its origin to the indentation of the lower side of the horizontal seed in Schinus by a thickening or elevation of the receptacle in that region.

The trinerved character and the shallow sinus of the cotyledons prevail in species of other genera, where the outline differs considerably from that of Schinus. This is so in the case of Rhus typhina (fig. 256), with spathulate-oblong cotyledons, and in Odina Wodier, having long, lanceolate, falcate cotyledons with short broad petioles.

A departure from the strictly aerial and foliaceous cotyledons is met with in Anacardium occidentale. Here they are large, fleshy, falcate, and directed to one side of the young stem, plano-convex, trinerved, and slightly reticulate on the back, but showing no trace of nerves on the upper surface. Another nearly similar case occurs in Buchanania latifolia (fig. 258), having obovate, unequal-sided, fleshy cotyledons with a thick and a thin edge. They conform to the interior of the seed and that again to the endocarp, to which they owe their peculiar shape. Immediately after germination they are both directed to one side of the stem as in subterranean cotyledons; but they ultimately spread out right and left. Thick, fleshy, and truly subterranean cotyledons occur in Rhus Thunbergiana (fig. 255), a South African species with almost dry, one-celled, one-seeded fruits from three-quarters to one inch broad. A more remarkable instance occurs in Mangifera indica (fig. 257), the fleshy, oblong, subterranean cotyledons of which are often lobed and sometimes proliferous, as shown in the figure.

The primary leaves of the seedling show considerable variation in the different types of the Order. Those observed may be grouped under three very distinct types, namely, (1) those reduced to scales, (2) simple but foliaceous leaves, and (3) compound leaves. The first five leaves of Rhus Thunbergiana are minute scales; while all succeeding ones are simple, and penninerved. The first six at least of

Mangifera indica are scale-like ; the ultimate ones long, simple, and entire.

Where the primary leaves are foliaceous and simple, the first two are opposite, although succeeding ones are alternate. Examples of this occur in Buchanania latifolia, Schinus terebinthifolius, Odina Wodier, and Duvaua dependens. An exception occurs in Anacardium occidentale, where the first four leaves are crowded together and oblong-elliptic. The ultimate ones are also simple and entire, while those of Duvaua are entire or sinuate. The third leaf of Schinus terebinthifolius is trifoliolate, while the eighth one in Odina Wodier is the first to attain that state of development.

The only case of the primary leaves being compound coming under my observation, occurs in Rhus typhina, where the first three at least are trifoliolate, with the terminal leaflet much the largest and deeply incised. The first two only are opposite. Compare this with the seedling of Ailanthus glandulosa amongst the Simarubeæ.

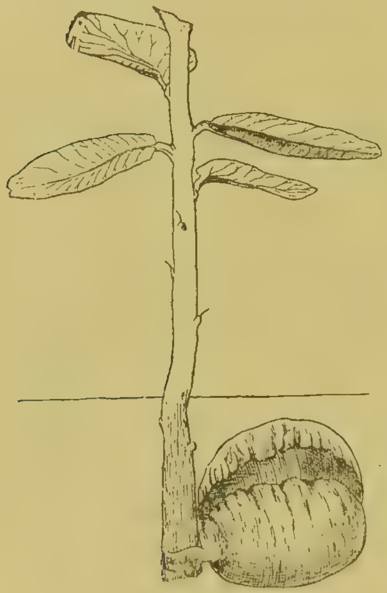

Fig. 255.—*Rhus Thunbergiana.* Half nat. size.

Rhus Thunbergiana, *Schult.* (fig. 255).

Hypocotyl subterranean.

Cotyledons large, fleshy, persistent, plano-convex, subterranean, wrinkled, pale yellow, petiolate, and both lying on the same side of the stem, 2·6 cm. long, 1·3 cm. wide, 8–10 mm. thick; petiole about 6 mm. long,

Stem woody, erect, terete, glabrous, reddish at first, then becoming covered with a glaucous-white bloom, then pale green, ultimately brown; internodes short: 1st 1·7 cm. long; 2nd 5·75 mm.; 3rd 1·15 cm.; 4th 6 mm.; 5th 7·5 mm; 6th 4 mm.; 7th 6 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, glabrous, coriaceous, rigid, horizontal, alternately penninerved with numerous parallel veins at right angles to the midrib and running straight to the margin, simple, or more often forked and sometimes forking again near the margin, brown and glossy at first, becoming covered with a glaucous bloom, ultimately light green; petioles very short, subterete, shining.

Nos. 1–5. Reduced to small, subulate, acute, discoloured scales.

Nos. 6–22. Oblong-oval, obtuse, emarginate, otherwise entire, gradually larger in order of development.

Rhus typhina, *L.* (fig. 256).

Primary root tapering downward at an obtuse angle into the soil, dark-coloured, with a few lateral rootlets, and soon equalled or superseded by strong lateral rootlets immediately beneath the soil, covered with root-hairs.

Hypocotyl erect, terete, glabrous, crimson, 12–28 mm. long.

Cotyledons spathulate-oblong, obtuse, tipped with a glandular mucro, slightly falcate, petiolate, trinerved from the base, glabrous except the petioles, dull green above, paler beneath, when fading of a rusty red or crimson colour; lamina 5–9·5 mm. long, 2·5–4·5 mm. wide; petioles channelled above, convex beneath, dilated and slightly connate at the base, and again dilated into the lamina, slightly hairy on the margins above, 1·75–4·5 mm. long.

Stem erect, terete, hairy, with simple glandular hairs; green, reddish, or crimson, ultimately shrubby; 1st internode 2·25 mm. long; 2nd and 3rd each about ·5 mm.

Leaves compound, imparipinnate, cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved with the nerves running straight into the teeth and divisions, somewhat hairy above and at the margins; hairs simple, glandular; deep green above, glaucous beneath, when fading of a rusty red or yellow and crimson colour; petioles semiterete, channelled above, coarsely hairy with simple glandular hairs, generally red.

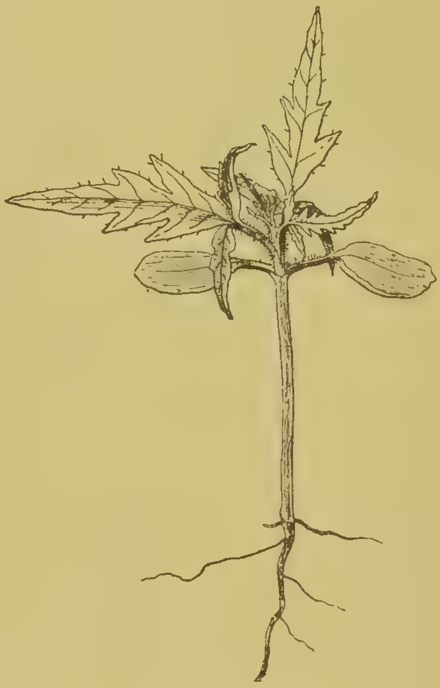

FIG. 256.—*Rhus typhina.* Nat. size.

Nos. 1–3. Trifoliolate; lateral leaflets narrowly lanceolate, acuminate, acute or subacute, more or less distinctly serrate in the lower half, sessile; terminal leaflet rhomboid-lanceolate, acuminate, subacute, cuneate at the base and very shortly petiolate, coarsely serrated on the lower half, with two ovate, subacute, decurrent serratures on each side on the first two leaves, and three or more on the third leaf.

Anacardium occidentale, *L.*

Hypocotyl erect, terete, fleshy, covered with minute points, 2·5–3 cm. above the soil.

Cotyledons aerial, large, fleshy, falcate, directed to one side of the seedling stem, plano-convex, but deeply channelled at the base on the upper side, glabrous, yellowish-green, trinerved on the back, where they also distinctly show the short lateral nerves, and are slightly reticulate, nerveless on the upper surface, sessile, 4·4 cm. long in the bent condition, 10–12 mm. wide.

Stem erect, tapering upwards very much in the seedling stage, covered with minute glandular points, fleshy, ultimately woody; 1st internode 4–4·5 cm. long, appearing as if jointed to the apex of the hypocotyl above the cotyledons, where a bud is given off in the axil of each, thickened on one side with two elevated processes as if furnished with a sheath; 2nd and 3rd internode 2–3 mm. long; 4th shorter.

Leaves simple, entire, cauline, alternate, exstipulate, shortly petiolate, closely and alternately incurvinerved, bronze-coloured in the young state, and ultimately deep green, shining, glabrous.

Nos. 1–4. Oblong-elliptic, shortly acuminate, crowded.

Mangifera indica, *L.* (fig. 257).

Primary root very stout, tapering downwards, and giving off slender, lateral rootlets, dark-coloured.

Hypocotyl very short, stout, terete, glabrous, pale-coloured, with dark markings, 6–8 mm. long, 7–8 mm. wide.

Cotyledons oblong, obtuse, thick, fleshy, plano-convex, subterranean, cut away on the upper side at the base, and slightly auricled on the under and basal side, very shortly petiolate, about 5·7 cm. long, 2·5 cm. wide; petioles stout, fleshy, plano-convex, curved at right angles to the radicle to accommodate the latter in germination, 12–13 mm. long, 7·5 mm. wide.

They often become lobed, and sometimes proliferous, splitting transversely and forming a second embryo with two cotyledons corresponding to half the original ones or less.

When this is the case, a second plumule and radicle are developed similar to the original.

Stem erect, terete, glabrous, stout, tapering upwards, ultimately woody; 1st internode 5·4 cm. long; 2nd 4 mm. long; 3rd 4 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate.

Nos. 1–6. Small, reduced to scales.

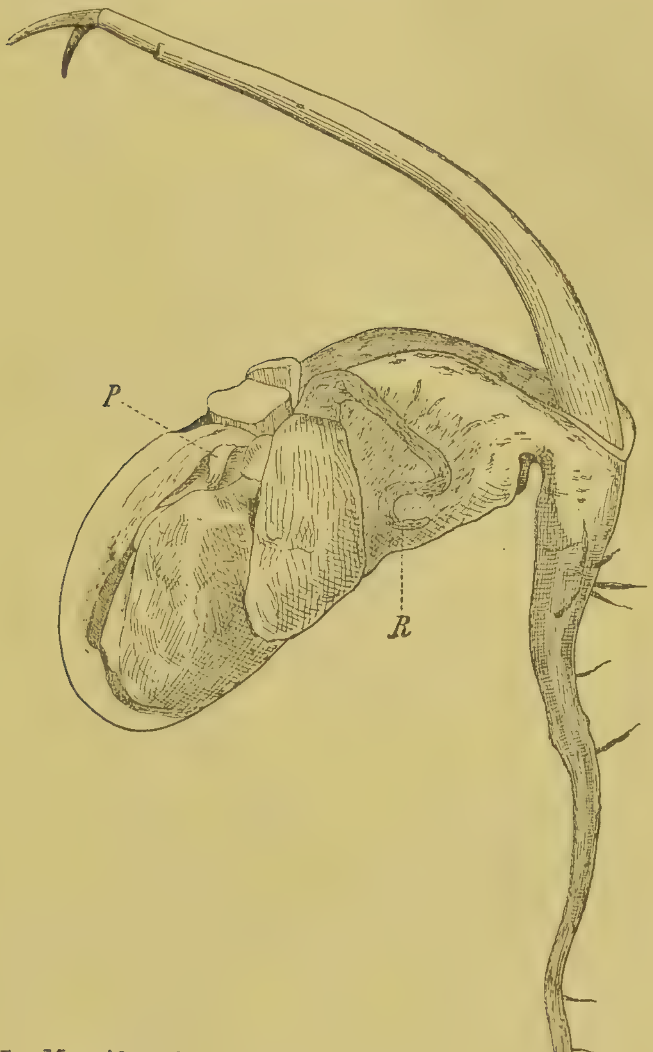

FIG. 257.—*Mangifera indica. P*, plumule of a second embryo or proliferation of the first or true embryo; *R*, the radicle of the same.

Buchanania latifolia, *Roxb.*

Fruit a drupe, with a small quantity of fleshy sarcocarp, one-celled, one-seeded, solitary by abortion; endocarp hard, bony, laterally compressed, especially near the apex, splitting vertically into two pieces during germination.

Seed transversely oblong, much compressed laterally, especially near the top, and conforming to the interior of the endocarp; testa thin, pale brown, marked on both sides by the branching chalaza, where the seed is discoloured; funicle stout, lying in an indentation round one end of the seed; micropyle superior.

Endosperm none.

Embryo large, curved, transverse to the axis, pale greenish-yellow or almost colourless, fleshy; cotyledons conforming to the interior of the seed and each occupying about a half of it, lying transversely to the basal placenta with their very much thickened edges towards it, and their thin indented edges to the apex of the endocarp, which is also indented and always much compressed, causing the cotyledons to be more or less asymmetrical; radicle at one end of the embryo, terete, obtuse, curved round the basal end of the cotyledons and pointing upwards.

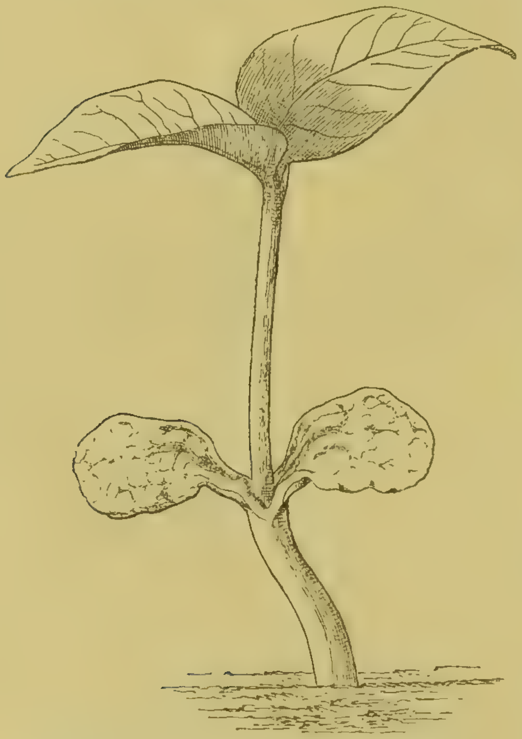

Fig. 258.—*Buchanania latifolia*, showing thin edge of cotyledons. Nat. size.

Seedling (fig. 258).

Hypocotyl erect, terete, fleshy in a very young state, glabrous, pale green, or tinged with red, soon becoming brown, 18 mm. long.

Cotyledons fleshy and soon falling away, obovate, very oblique or unequal-sided and also having one edge thin and the other thick, petiolate, glabrous, wrinkled or corrugated on the upper surface and margin, ribbed more or less conspicuously on the under-surface; lamina 6·5–7·5 mm. long, 5–5·5 mm. wide, 2 mm. thick at one edge and ·25 mm. thick at the other; petioles connate at the base, grooved above, convex on the back, 2–4 mm. long.

Stem erect, terete, succulent, ultimately woody, finely pubescent, pale green or reddish, soon becoming brown; 1st internode 1·5–3·3 cm. long.

Leaves simple, entire, cauline, alternate (first two opposite), exstipulate, petiolate, glabrous, or thinly glandular-pubescent on the midrib on both surfaces, alternately incurvinerved, with the nerves branching towards the margin and ending in a colourless cartilaginous line surrounding the leaf, shining green above, paler and shining beneath; petioles short, semiterete, channelled above, thinly glandular-pubescent.

Nos. 1 and 2. Lanceolate, obtuse, suddenly tapering to the base.

Schinus Molle, *L.* (fig. 259).

Fruit a drupe, one-celled, one-seeded; mesocarp fleshy or pulpy, very scanty; endocarp of two layers, of which the outer on the sides of the fruit is hollowed in several places forming oil receptacles; inner hard and bony.

Seed transverse to the receptacle of the fruit, irregularly oblong or subovate, suspended from the side of the cell, laterally compressed and conforming to the interior of the endocarp; testa thin; hilum and micropyle at one side of the ovary and superior or nearly so.

Endosperm irregular, surrounding the embryo, thick in some places and thin at others, fleshy, white.

Embryo comparatively large, nearly equalling the length and breadth of the endosperm, yellowish; cotyledons ovate, obtuse, entire, nearly or quite of the same thickness across the breadth of the seed, trinerved, often undulated in accordance with the undulated or wavy interior of the endocarp, with their basal edges to the

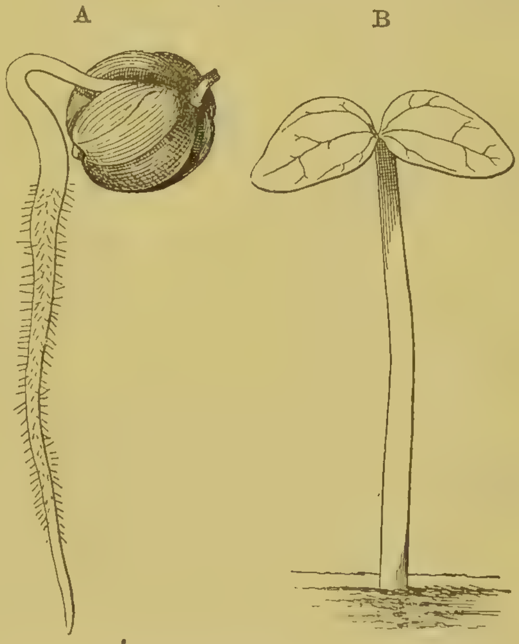

Fig. 259.—*Schinus Molle*, × 3. A, germinating seed. B, seedling four days after germination.

placenta; radicle terete, obtuse, ascending at the basal ends of the cotyledons.

Germination.—The primary root in germination pushes out at the side of the fruit through a narrow longitudinal slit between two of the numerous obtuse ridges formed by the swollen vittæ or oil-containing cavities. The primary root and hypocotyl are already stout, and the former is well furnished with root-hairs. The hypocotyl, having elongated and straightened, pulls the cotyledons out of the fruit.

Seedling.

Hypocotyl woody, erect, terete, finely pubescent, pale brown, about 13 mm. above soil.

Cotyledons ovate, obtuse, petiolate, coriaceous, glabrous, trinerved, reticulate; lamina slightly unequal at the base, 14 mm. long, 7·5 mm. broad; petioles channelled above, pubescent, 1·5 mm. long.

Stem woody, erect, terete, finely pubescent, pale brown; 1st internode 14·5 mm. long; 2nd 11 mm.; 3rd 8 mm.; 4th 11 mm.; 5th 8 mm.; 6th 18 mm.; 7th 14·5 mm.; 8th 18·5 mm.; 9th 13·5 mm.; 10th 11 mm.

Leaves compound (primary simple), cauline, alternate (first two opposite), exstipulate, petiolate, pubescent on the petiole and midrib above; leaflets alternately penninerved, subreticulate, deep green above with paler nerves, paler beneath; petioles semiterete, channelled above.

Nos. 1 and 2. Opposite, lanceolate, acute, acutely serrate, as are all the succeeding ones.

No. 3. Alternate, lanceolate, with a lobe on one side at the base.

No. 4. Lanceolate, with a lobe on each side at the base.

Nos. 5 and 6. Digitately trifoliolate; leaflets lanceolate, with the terminal one many times larger than the lateral ones.

No. 7. Imperfectly trifoliolate.

Nos. 8–12. Digitately trifoliolate; lateral pair small, lanceolate; terminal one lanceolate, elongate or oblong-lanceolate, many times larger than the lateral ones.

Ultimate leaves imparipinnate with eight to thirteen pairs of opposite or alternate, lanceolate, acute, acutely serrate leaflets; sessile and frequently cut away at the base on the posterior side; basal ones longest, gradually becoming smaller to the uppermost pair; terminal leaflet longest of all, lanceolate, acute, acutely serrate.

Schinus terebinthifolius, *Raddi.*

Fruit a drupe, globose, glabrous, bright scarlet when mature, tipped with the persistent base of the terminal style; epicarp thin, crustaceous; mesocarp pulpy; endocarp with oil receptacles as in S. Molle.

Seed conforming to the interior of the endocarp, transverse to the fruit, reniform, with the sinus lateral, laterally compressed and somewhat undulated, glabrous, pale brown; testa thin, membranous; funicle suspending the seed at one end; hilum and micropyle contiguous; raphe ventral as well as the chalaza, both lying in the sinus, deeper brown than the rest of the testa.

Endosperm as in S. Molle but much thicker at the backs of the cotyledons.

Embryo curved, large in proportion to the size of the seed, greenish-yellow, lying in the broadest plane of the seed, transversely to the axis of the fruit; cotyledons oblong or ovate-oblong, slightly cordate at the base, otherwise entire, accumbent, trinerved at the base, flat and closely applied face to face, often slightly twisted, lying with their edges to the base of the fruit and their lower edges obliquely to the lateral placenta; radicle terete, rather elongated, descending and parallel with the funicle and with its tip close to the micropyle.

Seedling (fig. 260).

Cotyledons ovate-oblong, subfalcate, very similar to those of S. Molle.

Stem as in S. Molle.

Leaves.—Nos. 1 and 2. Opposite, simple, ovate, acute, acutely serrate, alternately penninerved with the nerves running straight into the teeth.

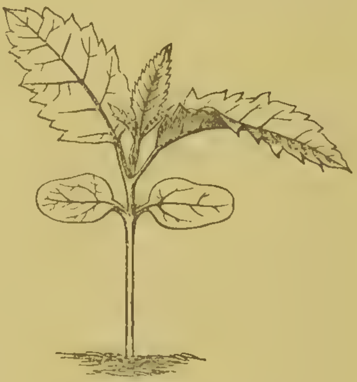

FIG. 260.
Schinus terebinthifolius.
Two-thirds nat. size.

No. 3. Alternate, trifoliolate; terminal leaflet much the largest, lanceolate, acute, acutely serrate; lateral ones similar, much smaller.

Odina Wodier, *Roxb.*

Hypocotyl erect, terete, glabrous, pale green, 2·5–3·5 cm. long.

Cotyledons lanceolate, falcate, obtuse, petiolate, entire, with a wide very shallow sinus on one side; lamina trinerved from base to apex, subcoriaceous, glabrous, deep green above, much paler beneath, 2·3–2·7 cm. long, 7–8 mm. wide about or below the middle; petiole flattened above, convex on the back, 3–3·5 mm. long.

Stem erect, terete, glabrous, green in the young state; 1st internode about 11·5 mm. long; 2nd 7·5 mm.; 3rd 6·5 mm.; 4th 8 mm.; 5th 8 mm.; 6th 6 mm.; 7th 2 mm.

Leaves simple at first, ultimately imparipinnate, cauline, alternate (first two opposite), exstipulate, petiolate, alternately incurvinerved and reticulate, glabrous, deep shining green above, much paler beneath; leaflets opposite (crenate-serrate in specimen, said to be entire); petioles semiterete, channelled above with rather acute edges, narrowed upwards from a stout base, glabrous, green.

Nos. 1 and 2. Lanceolate, subacuminate, obtuse, opposite, crenate-serrate, as are the following.

Nos. 3–7. Broadly ovate, subacuminate, obtuse, varying in size, rounded at the base or sometimes shallowly cordate.

No. 8. Trifoliolate; leaflets subelliptic, obtuse, sometimes shortly acuminate.

Duvaua dependens, *Kunth.*

Hypocotyl erect, terete, finely pubescent, pale green or usually reddish; 1·6–3·5 cm. above the soil.

Cotyledons oblong-oval or subovate, entire, obtuse, glabrous, deep green above, paler beneath, shortly petiolate, indistinctly trinerved at the base and with a few short alternate nerves upwards, all of which are seen only from the under side of the cotyledon; lamina 6–10 mm. long, 5–7 mm. wide; petiole about 1·5 mm. long, flat or slightly grooved above.

Stem woody, erect in seedling, terete, finely pubescent with decurved hairs, pale green or reddish; 1st internode 1·15–1·55 cm. long; 2nd generally undeveloped; 3rd 1–1·3 cm.

Leaves simple, cauline, alternate (first and second opposite), exstipulate, shortly petiolate, glandular-pubescent on the petiole and midrib, otherwise glabrous or nearly so, alternately penninerved, deep green, shining; petioles short, slightly channelled above.

Nos. 1 and 2. Ovate, acute, irregularly serrate.

Nos. 3–9. Ovate, acute, doubly serrate.

MORINGEÆ.

Benth. et Hook. *Gen. Pl.* i. 429.

Fruit and Seed.—The one-celled ovary of this Order is syncarpous, consisting of three carpels, with as many parietal placentas, and numerous, pendulous, anatropous ovules arranged in a double series. The raphe is ventral, and very prominent. The fruit is a long, torulose, three- to six- to twelve-angled, one-celled pod, bursting by three valves when mature.

The seeds are large, ovoid, three-winged or wingless, seated in a single row upon each of the placentas, and separated by a spongy development of the same; the wings and chalaza are corky or membranous. Endosperm is wanting, and the large fleshy embryo with almond-shaped cotyledons occupies the whole interior of the seed. The extremely short radicle is included between the bases of the cotyledons, and lies close to the micropyle at the hilar end of the seed. The plumule is well developed, and shows the primary leaves, which are compound.

Seedlings.—The Moringeæ constitute a very small Order, including only three species belonging to Moringa, the only genus.

The fleshy cotyledons of Moringa aptera are subterranean, and never leave the testa. The first six leaves are pinnately trifoliolate with entire or tridentate leaflets and linear, caducous stipules that appear filiform from being longitudinally revolute.

In other species the stipules are absent, or consist of glands sometimes stipitate.

The leaves of the adult are bipinnate, or simply pinnate towards the end of the branches, and ultimately simple and spathulate. All fall early, and the tree becomes leafless. The root of the seedling forms a fleshy tuber with a pungent taste like a radish, and is edible.

Moringa aptera, *Gærtn.*

Hypocotyl subterranean.

Cotyledons subterranean and remaining in the testa, plano-convex, fleshy.

Stem succulent in the seedling stage, soon becoming woody, erect, terete, glabrous, pale green suffused with red; 1st internode varying in length from 5–8·5 cm.; 2nd about 2·3 cm.; 3rd 1·2 cm.; 4th 8 mm.; 5th 5 mm.; 6th 3 mm.

Leaves compound, cauline, alternate, stipulate, glabrous, glaucous; leaflets articulated, deciduous, or caducous; petiolules minutely stipellate; petioles terete, tapering upwards, glabrous, glaucous; stipules linear or revolute longitudinally and appearing filiform, acute, reddish, caducous, and quite free from the petiole.

Nos. 1 and 2. Trifoliolate, less often five-foliolate; lateral leaflets oval, cuspidate, entire; terminal leaflet rhomboid, cuspidate, obsoletely serrate along the upper half.

Nos. 3 and 4. Trifoliolate; lateral leaflets as in Nos. 1 and 2; terminal leaflet obovate or subelliptic, minutely cuspidate, entire.

Nos. 5 and 6. Trifoliolate; lateral leaflets as before; terminal leaflet subrhomboid, trinerved, trifid, with triangular cuspidate lobes or teeth, the middle one of which is much the largest, otherwise entire.

Leaves of adult (a tree of 12 feet) bipinnate or simply pinnate towards the apex of the branches; ultimately on the slender branches they are opposite, simple, spathulate, entire, shortly petiolate, and hoary.

LEGUMINOSÆ.

Benth. et Hook. *Gen. Pl.* i. 434.

Fruit and Seed.—The pistil is monocarpellary with a few exceptions such as Swartzia dicarpa, Pultenæa obovata, and a few of the Cæsalpinieæ where there are two carpels. From two to five occur in Affonsea. The ovary is one-celled, and bears usually several or numerous ovules, arranged in one or two rows along the ventral suture, rarely only one ovule is present. The ventral suture faces the odd petal termed the vexillum in papilionaceous flowers. The ovules are superposed, amphitropous, or anatropous, and transversely ascending or pendulous. The fruit is termed a legume, and is strictly so when it is dry and dehisces along both the ventral and dorsal suture; but it is sometimes fleshy or pulpy, as in Tamarindus indicus, or dry, thick, leathery, and indehiscent, as in Ceratonia Siliqua, nut-like as in Arachis hypogæa, or rarely drupaceous. Sometimes it dehisces by the ventral suture only, like a follicle; in other cases, as in Hedysarum and in some species of Desmodium, it is lomentaceous. The internal cavity is continuous, or divided transversely by spurious septa, as in Entada, Tamarindus, some of the Cassias, Ceratonia Siliqua, and others.

The testa is coriaceous, bony, or greatly thickened, rarely membranous. The funicle is thickened, or arillate in many instances, or there is a thickened process near the hilum, termed a strophiole. Endosperm is wanting or scanty in the suborders Papilionaceæ and Mimoseæ; when present it is unequally distributed, and collected in greatest quantity round the radicle, so as to occupy the space not filled by the embryo. Swartzia madagascariensis, belonging to the Papilionaceæ, is exceptional in having small seeds with a copious endosperm. Albuminous seeds are the rule in the suborder Cæsalpinieæ, and in many of the species belonging to it the endosperm is copious and cartilaginous.

The embryo is large and occupies the whole of the seed where endosperm is wanting. The cotyledons are flat or plano-convex, and foliaceous, or thick, fleshy, and frequently subterranean in germination. The radicle in this case is superior, incurved, accumbent, and where it is of appreciable length it is so much curved as to come down on the ventral face. In such cases the ovule and seed are amphitropous. In some rare cases the radicle is inferior. The embryo is generally straight in the Cæsalpinieæ, particularly where a copious endosperm is present.

The seeds observed may be divided into two groups, namely those with, and those without, endosperm. This does not always indicate the closest affinities, although in most cases the two groups belong to different suborders. It may be convenient to subdivide the latter group into two, according to some peculiarity of the cotyledons. Phaseolus multiflorus (fig. 289) may be given as a type where the cotyledons are slightly unequal at the base, owing to the space being occupied by the radicle. This is more markedly the case in many or most species of Lupinus both before and after germination, including L. mutabilis, L. micranthus, and L. sulphureus. The cotyledons of the latter are also connate at the base. To this type the following agree in all general particulars, namely, Hedysarum neglectum, H. coronarium (fig. 280), Lathyrus macrorhizus, Vicia sativa, Astragalus galegiformis, and Canavalia virosa.

The seeds of those mentioned vary considerably in size and shape, in the amount of space occupied by the radicle, and the shape of the latter. In Lupinus mutabilis the radicle is trigonous, and in L. micranthus it is flattened and biconvex owing to pressure. In most cases the seeds are laterally flattened, and many of them are oblong, while others, such as Lathyrus odoratus, and L. macrorhizus, are globular. Those of Canavalia virosa and Phaseolus multiflorus are notable for their size. A rather exceptional case occurs in Caragana arborescens, where the cotyledons, although normally accumbent, are often obliquely so, and sometimes even incumbent. The cotyledons are occasionally unequal in thickness. The segments of the lomented fruit of Hedysarum coronarium and others are remarkable for the number of outgrowths or excrescences, often hooked, from their surface and sutures.

The second subgroup includes a considerable number of species the cotyledons of which are more or less indented on one side owing to a thickening or indentation at the hilum. This type may be represented by Clitoria Ternatea (fig. 286), which has a transversely oblong seed. The base of the cotyledons is also more or less unequal, or cut away on one side, owing to the space being occupied by the radicle as in the last subgroup. Here may be classed Ononis arvensis, Medicago sativa, M. rigida, Æschynomene aspera, and Swainsonia galegifolia.

In all these cases the seeds vary greatly in shape. Those of Ononis arvensis are nearly globular, and covered with small tubercles; in the species of Medicago there is a special development of the testa on one side of the seed to accommodate the radicle. The indentation on the side of the seeds of Æschynomene aspera is so deep as to make them curved or reniform. Those of Swainsonia galegifolia are broadly cordate and laterally compressed, unequally auricled at the base. The cotyledons are oblong, plano-convex, and unequal-sided, owing to the basal notch of the seed; the radicle is bent at right angles to the cotyledons along the basal edge of which it lies, and then projects beyond them into the smaller auricle of the seed, where it becomes embedded in a thickened portion of the testa at the micropyle.

Seeds containing endosperm may be subdivided into those having a curved or bent radicle, and those having an entirely straight embryo. The first is represented by Laburnum vulgare (fig. 266), Sesbania ægyptiaca, and Kennedya rubicunda. The cotyledons of all are unequal at the base owing to the position of the radicle, and indented at the sides owing to a thickening at the hilum. All three belong to the suborder Papilionaceæ, and have a small quantity of endosperm, except in the case of Sesbania ægyptiaca (fig. 276), where there is a considerable quantity on the backs of the cotyledons, which are therefore thin. A remarkable exception occurs in Scorpiurus sulcata, and other species, in which the embryo is variously twisted and narrow, with the intervening spaces occupied by endosperm.

The seeds having a straight embryo belong to the suborder Cæsalpinieæ. The radicle is slightly bent or curved in Cassia Sophora, and accumbent, thus forming a transition state between this and the last subgroup. A good type of the subgroup is shown in Cassia Fistula (fig. 301). The cotyledons are here more or less twisted. The outer coat of the seed becomes separated from the rest, forming a broad, white, torn band down the middle of both surfaces. Cassia Absus and Cercis Siliquastrum have orbicular cotyledons, notched at the base to accommodate the radicle. Cassia obovata is remarkable for the small size of its embryo, which may be due to the fact that the seeds are ruminated to a considerable depth from the periphery. The cotyledons are orbicular. In all the species of Cassia mentioned the endosperm is rather copious and cartilaginous or horny when dry.

Seedlings.—The prevailing type of cotyledons throughout the Order is oblong; but there are several important modifications, such as those having an indentation at the sides making them falcate, while others are unequal at the base. A third modification consists in cotyledons which are cordate or auricled at the base. Others are worthy of note, but it may be convenient to class them under the head of exceptional cases. Even in the typical oblong form there are numerous minor variations such as linear-oblong, broadly-oblong, oval-oblong, obovate-oblong, or spathulate-oblong. In all cases they conform to the shape and size of the seed, and the modifications to some peculiarity of the same, the development of the embryo, the presence or absence of endosperm in the seed, or in a few cases to subsequent growth, *i.e.* during or after germination. Forms of one, two, or three kinds are peculiar to certain tribes, so that in the subjoined classification it would be convenient to notice the various kinds occurring in their respective tribes as far as they have come under observation, and to note there the exceptional cases. This applies more particularly to the suborder Papilionaceæ than to the Cæsalpinieæ and Mimoseae, where endosperm is more frequently present, and the embryo is often straight.

SUBORDER PAPILIONACEÆ.

Tribe Podalyrieæ.—The cotyledons of Chorizema cordifolium (fig. 261) and C. ilicifolium are narrowly oblong and one-nerved. The first two leaves are sometimes opposite and obovate, emarginate, or obcordate, succeeding ones being alternate. Four pairs of the primary leaves of Pultenæa daphnoides are opposite, narrowly obovate, generally apiculate, and all are simple. Podalyria australis has broadly oblong cotyledons and alternate leaves, the first being obovate and simple, while succeeding ones are digitately trifoliolate. A very striking exception occurs in Viminaria denudata (fig. 262), with linear cotyledons. The leaves show a curious case of the gradual abortion of the lamina and the elongation of the petioles. The seventh, eighth, and ninth have three minute teeth at the apex of the petiole as the representatives of as many aborted leaflets.

Tribe Genisteæ.—Cotyledons conforming to the leading oblong type are shown by Hovea longifolia, Goodia lotifolia, Retama Rœtam, Ulex europæus (*fig.* 268), and species of Cytisus. The first three leaves of Goodia lotifolia are pseudo-verticillate, a very rare circumstance. Two are broadly ovate and simple, while the third leaf is pinnately trifoliolate and inserted at right angles to the other two, but on the same level, owing to the internode not being developed. The first seven leaves of Retama Rœtam are simple, alternate, and smaller than the cotyledons. A remarkable amount of variation is noticeable in the leaves of different seedlings of Ulex europæus. In some the leaves are all simple, in others the primary leaves are simple, while those that succeed them are trifoliolate; in other cases the leaves are all trifoliolate. They are opposite or alternate apparently indiscriminately. All ultimately become modified into simple spines, or may be altogether aborted, while the branches form compound or branching spines.

Two of the leading modifications occur in this tribe, with some exceptional cases. Bossiæa linophylla (fig. 263) shows oblong cotyledons slightly indented at the sides, a peculiarity due to a thickening or an indentation at the chalaza of the seed. Others agreeing with this type are B. rufa, Laburnum alpinum, L. vulgare (fig. 267), Genista, Crotalaria quinquefolia, and other species of Crotalaria. The indentation is very marked in the last genus. Spartocytisus nubigenus has spathulate cotyledons and is somewhat exceptional in that respect; the first four leaves are digitately trifoliolate with narrowly linear leaflets. Bossiæa linophylla has the first three leaves like those of Goodia lotifolia except that the odd one, like the two following, is simple. All the five are obcordate, while the ultimate leaves are linear. The first five leaves of B. rufa are oval-elliptic, the first pair being opposite, the rest alternate. The first leaf of Crotalaria quinquefolia is obovate, obsoletely trifid, and alternate, but in other species the first pair are opposite. The leaves of the two common species of Laburnum are alternate and digitately trifoliolate from the first. A second well-marked modification is met with in the genus Lupinus. The cotyledons are unequal at the base, a peculiarity due to the radicle being sharply bent round their basal end in the seed, thus occupying the space that would otherwise be appropriated by them. Lupinus arboreus (fig. 264), L. elegans, L. micranthus, and others represent this type. The cotyledons are generally petiolate; but in L. linifolius they are subsessile and strongly falcate, being quite exceptional. A more unusual case occurs in L. sulphureus (fig. 265) and L. recurvatus, where the cotyledons are strictly sessile and connate along the whole of their basal edges. Those of the former are suborbicular, and the peculiarities exist while the embryo is still in the seed. The leaves of the various species of Lupinus are digitately compound from the first, with linear or lanceolate leaflets varying greatly in number.

Tribe Trifolieæ.—As far as shape is concerned, the leading type of cotyledons is the prevalent one in this tribe; they are usually small and narrowly oblong. The first leaf is simple or consists of one leaflet, while succeeding ones are pinnately trifoliolate. To this tribe belong Pocockia cretica, Trigonella corniculata, T. gladiata, Medicago maculata, M. orbicularis (fig. 271), Melilotus officinalis, M. parviflorus, M. albus, M. leucantha, Trifolium Boissieri (fig. 272), T. repens, T. redenakum, T. minus, T. subterraneum, and others. The lamina of the cotyledons is often articulated with its petiole, notably in the species of Trigonella, Melilotus, and Trifolium. A slight departure from the above type is met with in Ononis Natrix (fig. 270) and O. ornithopodioides, where the cotyledons are broadly oblong or broadly ovate and hairy, or glandular-pubescent. The first three leaves of Ononis rotundifolia and first four of O. ornithopodioides and O. Natrix are simple, while those that succeed are pinnately trifoliolate; but these numbers may vary in different individuals. The cotyledons of Trigonella Fœnum-græcum are chiefly notable for their size.

Cases of severe competition amongst the seedlings of a single fruit occur in species of Medicago where the indehiscent spirally coiled pod contains a large number of seeds. This is well represented by M. orbicularis.

Tribe Loteæ.—A few cases occur in this tribe, as in the Genisteæ where the cotyledons are falcate, as in Lotus biflorus, or indented on the sides, as in Anthyllis Vulneraria (fig. 273). The first three leaves at least of the latter species are elliptic and entire. An exception to the prevalent form occurs in Lotus peliorhynchus, where the cotyledons are linear or linear-oblong, and the first leaf is digitate with five narrowly linear hairy leaflets. A more remarkable deviation, not only from the type in the tribe, but from the Papilionaceæ generally, occurs in Lotus Tetragonolobus, where the cotyledons are broadly oblong and cordate at the base. The leaves are pinnately trifoliolate from the first. Instead of one axis taking the lead in this species, two stems, apparently of equal strength, are developed, together with a pair of smaller ones, as if the plumule before or during germination divided into four. This was so in the case of seventy-six out of one hundred and nine seedlings observed. It is most probable, however, that the supernumerary axes arise from the axils of the cotyledons. A similar thing takes place in L. biflorus, where four or more axes are developed at an early stage of the seedling. A better illustration is afforded by L. peliorhynchus, where the primary axis becomes decumbent, but maintains its supremacy while other axes varying in number from three to seven spring up in succession, apparently by adventitious budding from the same level as the primary one or even below it, displacing the latter.

Tribe Galegeæ.—A large number of species belonging to this tribe have cotyledons of the prevailing type of the Order. A number of them resemble those of the Trifolieæ generally in being narrowly oblong; and a good proportion recall Laburnum by the cotyledons being indented on the sides. Narrowly oblong types are represented by Indigofera australis (fig. 274) and other species, also by Galega officinalis, Carmichælia pilosa, Sesbania ægyptiaca, S. coccinea, and Swainsonia oncinotropis. The elongated and oblong-spathulate cotyledons of the latter appear to be due to growth after germination. A curious case occurs in Sesbania coccinea, where the cotyledons have an interpetiolar, subulate stipule. Out of thirty seedlings twenty-one had the first pair of leaves simple and opposite, while the other nine had the first leaf only simple. The solitary leaflet always terminated the petiole, but from the third leaf onwards the leaves are abruptly pinnate. The first pair of leaves in this species and in Indigofera australis (fig. 274) being opposite and simple recalls what occurs in the tribe Phaseoleæ as described below. The early stage of Galega officinalis recalls that of a Trifolium or Melilotus. This is also the case with Carmichælia pilosa, but the first four leaves at least are simple, obcordate, and small. The leaves of the adult plant are often exactly similar to the primary ones, but some of them are pinnately trifoliolate or imperfectly so. Broadly oblong-oval cotyledons occur in Robinia Pseud-Acacia (fig. 275) and in some species at least of Colutea. The first leaf of the former is simple and the second pinnately trifoliolate. Both this species and Indigofera australis as well as Galega officinalis show a gradual evolution of the leaves.

Large and broadly oblong cotyledons more or less falcate and sinuate on the sides or unequal at the base occur in Psoralea sp., Sesbania tomentosa (fig. 277), S. grandiflora, Calophaca grandiflora, in a new, unnamed species of Calophaca, Astragalus juvenalis, and A. thianschanicus (fig. 278). Those of A. sulcatus are much smaller, and both turned to one side of the stem, as are also those of the unnamed species of Calophaca, and Astragalus juvenalis. This phenomenon, together with the shortness of the petioles and the fleshy character of the lamina generally, indicates a tendency on the part of the cotyledons to become subterranean. The first leaf of Astragalus sulcatus is generally digitately trifoliolate, while the second bears only the terminal leaflet, but individuals may vary; and there is a gradual evolution of the leaves from those of the small or weak seedling to the adult plant which has imparipinnate leaves with very numerous leaflets. The other species of Astragalus above-mentioned also show a very gradual evolution of the leaves. The two first leaves of Psoralea sp. are cordate and opposite. All the four species of Sesbania above-mentioned show a remarkably abrupt form of evolution. The first leaf of S. grandiflora is lanceolate-oblong, of considerable size, and simple, while the second leaf is abruptly pinnate with four pairs, and the third with five pairs of narrowly oblong leaflets. The first leaf of S. tomentosa is obovate-oblong and simple, while the second and third are abruptly pinnate with three and four pairs of small, oblong leaflets respectively.

Two well-marked exceptions in this tribe occur in Amorpha glabra and Indigofera hirsuta, which have oblong trinerved cotyledons with a cordate or auricled base. The first four leaves of Amorpha glabra bear only one suborbicular leaflet, while the fifth and sixth are pinnately trifoliolate. All have stipules at the base of the petiole and stipellæ near the base of the leaflets. The first two leaves of Indigofera hirsuta are lanceolate and opposite, and succeeding ones alternate.

Tribe Hedysareæ.—Two well-marked types of cotyledons occur in this tribe as well as some remarkably abnormal forms. In the species of Hedysarum the cotyledons are rotund-obovate, very broad, fleshy, and opaque, with rather obscure venation, and both very strongly directed to one side. They owe their size and shape to that of the seeds, which again is due to the interior of the one-seeded segments of the lomented indehiscent fruits. In these respects Hedysarum coronarium (fig. 281), H. capitatum, H. obscurum, H. denticulatum, and H. flexuosum agree. The first leaf of H. flexuosum and H. capitatum is pinnate with five small lanceolate and oblong leaflets respectively. The first three leaves of H. coronarium are simple, entire, and orbicular to oval-oblong; but the third one is pinnately three- to five-foliolate, with similar-shaped leaflets.

In germination the radicle pushes itself through the end of the lomentum or through one suture, while the cotyledons make their exit by the other, as in H. coronarium (fig. 281) and H. obscurum. The wall of the fruit in H. denticulatum (fig. 279) is thin or membranous and reticulate, and the radicle generally pierces one valve, while by the swelling of the cotyledons and the elongation of the hypocotyl the lomentum is burst open and the upper valve pushed upwards, permitting the exit of the seedling. The testa is frequently carried up on the cotyledons, but the breadth of the latter and their increasing size soon splits it open and gets rid of it. Whatever the mode of exit of the radicle and cotyledons, the wall of the fruit nearly always gets pinned to the ground while the seedling rises clear above it. Thick-walled fruits last a long time in good condition after the germination of the embryo. Desmodium canadense has ovate-oblong, subfalcate cotyledons, and behaves exactly in the same way as Hedysarum during germination, but more frequently carries the fruit and seed above ground before it divests itself of them. Broadly-oblong subfalcate cotyledons with the sinus on one side occur in Æschynomene aspera (fig. 282), Lourea Vespertilionis (fig. 283), Lespedeza striata, and L. angustifolia. The leaves of Æschynomene aspera are abruptly pinnate from the first with numerous oblong leaflets. The first five at least of Lourea are transversely oval or oblong, gradually increasing in size. Those of the adult are simple or trifoliolate, with the lateral leaflets very small and as a rule falling very early. The cotyledons of Lespedeza are turned to one side and densely pubescent. The two primary leaves of L. striata and L. juncea are simple and opposite, followed by alternate and trifoliolate ones. In the other two species the first leaf only is simple. Several remarkable exceptions to any of the prevalent types of the Order occur in this tribe. The cotyledons of Lespedeza juncea are subterranean, or if they rise above ground they perish early. Those of Coronilla juncea and Ornithopus repandus are obovate-spathulate, tapering to the base and shortly connate there, reminding us of what occurs in Pocockia cretica amongst the Trifolieæ and in Swainsonia oncinotropis amongst the Galegeæ, but here more pronounced, and evidently due to the same cause. The first leaf of the Coronilla is obovate and simple, while that of the Ornithopus mentioned is oval-oblong. The second leaf in both cases is trifoliolate, but the lateral leaflets of Ornithopus are minute and suborbicular and quite distinct from the subulate stipules, which are connate by their posterior edges and sheathe the stems. The cotyledons of Adesmia muricata are cordate-oblong and succulent. The first leaf is five-foliolate, while succeeding ones are abruptly pinnate with a varying number of leaflets.

The cotyledons of Hippocrepis ciliata are narrowly linear, fleshy, tapering downwards, and from 1·8 to 3 cm. long. Their shape seems to be due to that of the seed and to subsequent growth in length while still retaining a similar shape. The first leaf bears three leaflets, and succeeding ones a greater number, on the imparipinnate plan. The most remarkable exception, however, occurs in Scorpiurus sulcata, where the cotyledons are cylindrical, fleshy, and deeply furrowed on the upper side. The primary cause of this is the manner in which they are twisted about in the albuminous seed. They elongate greatly during and after germination, but retain their original form. Two days after leaving the seed they measure from 1·8–2·2 cm. in length, and after twenty-four days from 7·5–8·2 cm.

Tribe Viciecæ.—Of all the seedlings belonging to this group and coming under my observation, Abrus precatorius is the only species observed which conforms to the prevalent type of the Order in having oblong-obovate, aerial cotyledons. Even these show a tendency to become subterranean in being fleshy, opaque, sessile, and both slightly directed to one side. The first two leaves are opposite, and all are abruptly pinnate, with numerous opposite pairs of oval or oblong leaflets.

Other members of the tribe have globose or oblong seeds with fleshy, hemispherical or plano-convex subterranean cotyledons. Species conforming to this type are Vicia andicola, V. Faba, V. sativa, Lathyrus Nissolia (fig. 284), L. Aphaca (fig. 285), L. sylvestris, L. latifolius, L. odoratus, L. brachypterus, and L. articulatus. The first three leaves of Vicia andicola are small and tridentate, the lateral teeth being the stipules. The next three leaves are abruptly pinnate with one pair of leaflets, the midrib of the fourth ending in a curved point, and succeeding ones in a tendril. The cotyledons of V. Faba are oblong as are those of Lathyrus brachypterus. The first four leaves of the latter are trifid, small and scale-like, while the next one bears a pair of leaflets. The stem of L. Nissolia is erect, and generally if not always hooked or twisted at the apex. The first two leaves are scale-like, subulate, and carinate. Succeeding ones are narrowly linear, entire, sessile, stipulate, and convolute in bud, enclosing the younger leaves. A very similar case is presented by L. articulatus, but the leaves gradually increase in length from the first (which is very short) to the fifth; and as the stem increases in length, requiring support, the tip of the leaf from the fifth or the sixth onwards forms a small, simple tendril. The stem is four-winged owing to the leaves being decurrent at their bases. The stipules on the lower leaves are more or less adnate to the edges of the latter, with subulate, free points, becoming triangular higher up, and ultimately becoming wholly adnate or entirely aborted.

Tribe Phaseoleæ.—As far as the cotyledons are concerned, there are two very distinct types of seedlings in this tribe, with several intermediate forms. All, however, agree in the first two leaves being simple and opposite, with generally very short petioles. The ultimate leaves are pinnately trifoliolate.

The type with aerial cotyledons is represented by Clitoria Ternatea (fig. 286). They are oblong, falcate or indented on one side, a peculiarity already described. Others agreeing with this are Butea frondosa, Pueraria Thunbergiana (fig. 288), and Centrosema Plumieri. Dolichos falcatus differs in having oval, fleshy cotyledons; Erythrina monosperma in having oblong, fleshy, and slightly concave cotyledons; and Phaseolus vulgaris (fig. 290) in having them oblong, falcate, fleshy, and directed to one side of the stem. In all three cases they exhibit a tendency to become subterranean, but are carried above ground by the extraordinary vigour of the plants and the elongation of the hypocotyl. The first pair of leaves in Dolichos falcatus are cordate; those of Erythrina monosperma are very much larger and rotund-cordate, emarginate, and very deeply auricled, almost sagittate at the base, with the third leaf compound. Phaseolus vulgaris conforms very nearly to the latter. Those of Pueraria Thunbergiana are roundly rhomboid, and those of Centrosema Plumieri oblong-cordate. A case of more gradual evolution occurs in Clitoria Ternatea, which has the first pair of leaves small and lanceolate, while the third is obovate, emarginate, and much larger. The fourth is broadly oblong, emarginate, and many times larger than the first two, but in some individuals the fourth leaf is trifoliolate or imperfectly so. The fifth and sixth leaves are pinnately trifoliolate, with small oval or elliptic leaflets.

The cotyledons are strictly subterranean in Erythrina Vespertilio, Phaseolus multiflorus, Vigna lutea, V. vexillata, Pachyrhizus angulatus, Rhynchosia viscosa, Flemingia Grahamiana, &c. The first pair of leaves in the last species are small and rotund, while those of Rhynchosia viscosa are cordate. The lamina of the first pair in Pachyrhizus angulatus is broadly triangular. Immediately above these the stem becomes slender and twining, as also in Vigna vexillata. The first pair of leaves and the leaflets of the succeeding ones in the latter are comparatively small and lanceolate. The first pair in V. lutea are ovate-subcordate. Lateral shoots from the axils of the cotyledons in Phaseolus multiflorus are produced if the primary axis gets destroyed, and the first leaf on them is simple and subrotund. The first four leaves of Erythrina Vespertilio are transversely rhomboid; the fifth has small rhomboid leaflets. Many of the above species have small subulate stipules and stipellæ. A very curious case occurs in a plant questionably named Erythrina suberosa (fig. 287). The cotyledons are subterranean, and the first pair of leaves opposite; but four at least of the primary ones are simple, trifid, or trilobed, subpalmate and palmately five-nerved.

The most striking exception observed in the tribe occurs in Kennedya Marryattæ. The cotyledons are linear-oblong, fleshy, sessile, furrowed beneath, and 2·6–3 cm. long. The first pair of leaves are suborbicular, simple, and often unequal in size.

Tribe Dalbergieæ.—Few of the species of this tribe have come under my notice, and those show modifications of the leading type. Dalbergia hupeana has obliquely ovate cotyledons cut away at the base on one side. The first two leaves are opposite with five obovate leaflets. The cotyledons of Lonchocarpus latifolius (fig. 292) are fleshy, but aerial and falcate by an indentation on one side. The first two leaves are opposite, ovate, and simple, reminding one of what occurs in the Phaseoleæ. The third leaf is alternate. The sixth to the eleventh inclusive have eleven leaflets.

Tribe Sophoreæ.—All the species observed in this tribe have subterranean, fleshy cotyledons, varying considerably with the seed in shape, size, and thickness. Sophora secundiflora (fig. 293) has obovate somewhat oblique cotyledons, and the first seven leaves at least are alternate, simple, entire, and variable in shape and size. The cotyledons of Edwardsia chilensis (fig. 294) are fleshy and green; and the leaves show a gradual evolution from the first, which is small, obovate, and simple. A rather exceptional case occurs in Castanospermum australe (fig. 295), which has depresso-globose, fleshy cotyledons of enormous size. It is comparable to a species of Cola,[1] one of the Sterculiaceæ, but in the latter there are four cotyledons.

Myroxylon peruiferum has also subterranean cotyledons. The two first leaves are five-foliolate and opposite, succeeding ones have more numerous leaflets, the uppermost of which are the largest and the basal ones the smallest. The leaflets are all lanceolate.

SUBORDER CÆSALPINIEÆ.

Tribe Eucæsalpinieæ.—In the suborder Papilionaceæ cotyledons with a cordate base are comparatively rare, while in the Cæsalpinieæ they are very frequent. This is due to a difference in the seed and embryo, the former generally containing endosperm, while the latter is straight, and the radicle is included between the auricles of the cotyledons, or projects slightly beyond them. The embryo is nearly as long as the endosperm, but differs considerably in outline in different species according to the shape of the seed.

The cotyledons of Cæsalpinia tinctoria (fig. 297) are orbicular with a cordate base, strongly trinerved, with the nerves branched. The leaves are stipulate and stipellate; the first two are abruptly pinnate with four pairs and three pairs of leaflets respectively. The third leaf is abruptly bipinnate, with one pair of pinnæ, each of which bears three pairs of leaflets. The cotyledons of Poinciana Gilliesii (fig. 298) differ in being oblong and five-nerved. The first leaf is abruptly pinnate.

One of the most remarkable exceptions occurring in the whole Order is met with in Hæmatoxylon campechianum (fig. 296). The cotyledons are bipartite, with divaricate unsymmetrical lobes of membranous texture.

Tribe Cassieæ.—The various species of the genus Cassia differ considerably amongst themselves. The cotyledons of C. mimosoides represent the typical form of the Order in being oblong, and those of C. Fistula (fig. 302) differ only in being obovate-oblong. In both cases the primary leaves are abruptly pinnate. A departure from the type is met with in Cassia obovata (fig. 300), which has broadly obovate, retuse, trinerved cotyledons. C. Absus is more in accordance with the type of the suborder, having orbicular trinerved cotyledons with a cordate base. C. circinata (fig. 299) differs from the latter only in the cotyledons being entire. The leaves are abruptly pinnate, the first having a single pair of leaflets, and the next four two pairs.

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[1] *Vide supra*, p. 270.

Tribe Bauhinieæ. — There is a considerable similarity amongst the seedlings of the representative genus Bauhinia, the chief differences being in minor details. The cotyledons are broadly oblong or obovate-oblong, usually sessile and three- to five-nerved, sometimes indistinctly. Bauhinia tomentosa (fig. 303) and B. Carronii are good representative types. The shape of the cotyledons is due to that of the seed, which is oblong or suborbicular and flattened, with the contained cotyledons flat, but rather fleshy. Those of B. Carronii show a tendency to become subterranean. The seeds of this species measure 9–10·5 mm. long, 6–8·5 mm. wide, and 2·25–2·75 mm. thick, while those of B. tomentosa, having decidedly aerial cotyledons, are smaller in every way. The cotyledons of B. corymbosa and B. Hookeri agree in general particulars with the above, but are rather fleshy and do not readily unfold to the light.

The leaves of B. Hookeri and B. Carronii are abruptly pinnate from the first, and consist of one pair of obovate, sessile leaflets, differing only from those that succeed them in being smaller. Those of B. corymbosa and B. tomentosa consist of one pair of leaflets united in a single bifid or bipartite piece; and in all or most cases the midrib projects as a short bristle between the leaflets or lobes. The cotyledons of Cercis Siliquastrum (fig. 304) are orbicular, entire, shortly petiolate, and trinerved; while the leaves are reniform, or roundly cordate and five-nerved.

Tribe Amherstieæ.—The only seedlings of this tribe whic have come under my notice are Hymenæa Courbaril (fig. 305) and Peltogyne sp., having plano-convex, fleshy, erect, oblong, and emarginate cotyledons, with auricles at the base clasping the stem. Cotyledons possessing the last-named character are met with amongst the Acacias. The leaves in Hymenæa Courbaril are compound, and consist of one pair of leaflets. Those of the first leaf are suborbicular, emarginate, exstipulate, and sessile, owing to the adhesion of the petiole to the stem, giving them the appearance of simple, opposite leaves; but they are both inserted towards one side of the stem. The second leaf is stipulate with a pair of obliquely-ovate leaflets, while the adult one has obliquely-oblong or falcate leaflets. The first two leaves of Peltogyne are opposite and abruptly pinnate, with three pairs of lanceolate leaflets and the midrib prolonged between them.

Tribe Cynometreæ.—The cotyledons of Copaifera officinalis are very similar to those of Hymenæa Courbaril. The leaves are abruptly pinnate, coriaceous, glabrous, evergreen and full of pellucid dots, and penninerved, with short, stout, cylindrical petioles. The first leaf has three pairs of lanceolate, falcate leaflets, oblique on the posterior and more or less cut away on the anterior side at the base, especially the uppermost pair. Succeeding leaves have more numerous leaflets.

SUBORDER MIMOSEÆ.

Tribe Adenantheræ.—The cotyledons of Adenanthera Pavonina (fig. 306) are broadly obovate, sessile, erect, fleshy, auricled at the base, and in this respect resemble those of the two above-mentioned species. The leaves are alternate except the first pair, which are opposite and abruptly pinnate, with numerous alternate leaflets. The leaves of the adult are large, and abruptly bipinnate with three to four pairs of pinnæ. The cotyledons bear small buds in their axils. Those of Prosopis juliflora are broadly oblong, subsessile, and caducous. The first leaf is abruptly pinnate, with four pairs of small, oblong leaflets like those of an Acacia. The second to the seventh leaves inclusive are abruptly bipinnate, with numerous small leaflets, and the midrib generally prolonged as a small bristle beyond the pinnæ. The cotyledons of

Dichrostachys cinerea are oblong-ovate, cordate at the base, shortly petiolate, and in this respect unusual in the tribe. The first leaf is inserted nearly on the same level as the cotyledons, and is abruptly pinnate with numerous very small leaflets. The second leaf is abruptly bipinnate with one pair of pinnæ, but the number of the latter increases in succeeding leaves.

Tribe Eumimoseæ.—The cotyledons of Leucæna glauca (fig. 307) are obovate, sagittate at the base, shortly petiolate, five-nerved, and horizontal, differing in this respect from most of its allies. The first leaf is abruptly pinnate, with numerous pairs of unequal-sided leaflets. The three succeeding ones are bipinnate with a pair of pinnæ each.

The cotyledons of Mimosa lanata are roundly oblong, three- to five-nerved, truncate at the base and auricled. The first leaf has three pairs of leaflets ; the second is like that of Leucæna glauca.

Tribe Acacieæ.—The species of Acacia differ remarkably even in the shape and character of the cotyledons ; indeed, no two species have the latter exactly alike. In A. dodoneæfolia they are broadly oblong, sessile, and connate at the base, recalling those of Lupinus sulphureus. The first leaf is abruptly pinnate with four pairs of leaflets, as happens also in A. acanthocarpa. The cotyledons of the latter have a broad shallow sinus at the base. The first leaf is also abruptly pinnate in A. dealbata (fig. 310), A. lophantha, and A. Oswaldi. Two succeeding leaves in the latter case are pinnate, but it seems that subsequent ones gradually or immediately lose all their pinnæ, and their leaves are represented by lanceolate trinerved phyllodes.

The second leaf in A. lophantha, and A. dealbata (fig. 310), is bipinnate. The short, linear-oblong, caducous cotyledons of the latter seem quite unusual in the genus. Those of A. Oswaldi are obovate-oblong, and sagittate at the base. A most remarkable development of the basal auricles occurs in A. Burkittii (fig. 308). The first six leaves are bipinnate, with one pair of pinnæ each and numerous pairs of narrowly oblong leaflets.

Tribe Ingeæ.—The cotyledons of Pithecolobium Saman are caducous. The first leaf is abruptly pinnate, and succeeding ones bipinnate, with one pair of pinnæ and a varying number of leaflets. The latter are chiefly noticeable on account of the much greater size of the terminal ones compared with those towards the base of the pinnæ, where the pairs are often unequal. Their size, shape, and arrangement seem planned so as to economise space and at the same time expose a maximum surface to light.

TRIBE PODALYRIEÆ.

Podalyria australis, *Vent.*

Hypocotyl short, 3–4 mm. long, erect, terete, glabrous, bluish.

Cotyledons oblong, obtuse, entire, shortly petiolate, glabrous, green, one-nerved; petioles short, broad, furrowed on the upper side.

Stem erect, terete, herbaceous, ultimately shrubby; 1st internode 3–3·5 cm. long; 2nd rather shorter.

First leaf simple (rarely bi- or tri-foliolate), entire, cauline, stipulate, petiolate, obovately oblong, obtuse, glabrous, green, pinnatinerved; subsequent leaves trifoliolate, cauline, alternate; leaflets obovately oblong, obtuse, petiolulate, occasionally slightly emarginate; petioles very short, furrowed on the upper side; stipules free, linear-lanceolate, acute, rather large.

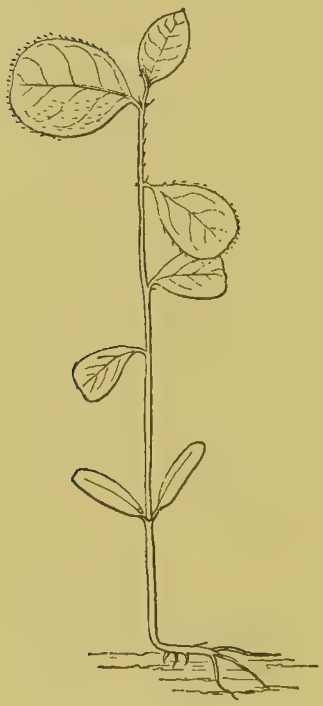
FIG. 261.
Chorizema cordifolium.
Nat. size.

Chorizema cordifolium, *F. Muell.* (fig. 261).

Hypocotyl erect, terete, glabrous, pale green, 1·3–2·5 cm. long.

Cotyledons oblong, obtuse, fleshy, shortly petiolate, deep green above, paler beneath, shining on both surfaces, falling away early; lamina 8·5 mm. long, 3 mm. broad; petiole 1·5 mm. long.

Stem erect, terete, pubescent, ultimately woody; 1st internode 1·8 cm. long; 2nd 5 mm.; 3rd 1 cm.; 4th 7 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, thinly pubescent on both surfaces and ciliate, ultimately glabrous or pubescent beneath and spiny-serrate, obscurely alternately penninerved, deep green above, subglaucous beneath; petioles terete, very short; stipules linear, slender, pubescent, caducous.

No. 1. Small, narrowly obovate, retuse, apiculate.
No. 2. Broadly obovate, emarginate, apiculate.
No. 3. Similar, and larger.
Nos. 4 and 5. Broadly oval, subemarginate, apiculate.

Ultimate leaves cordate, apiculate, spiny-serrate, irregularly alternately penninerved, with the nerves incurved and uniting with each other at or near the margin, reticulate, especially when dry, glabrous above or thinly pubescent, but pubescence denser beneath.

The seedling of **Chorizema ilicifolium**, *Labill.*, closely resembles the preceding, but the cotyledons are quite sessile.

Viminaria denudata, *Sm.* (fig. 262).

Hypocotyl erect, terete, glabrous, pale green: 1·3–2 cm. above the soil.

Cotyledons linear, obtuse, entire, sessile, articulated with the stem, glabrous, subfleshy, subconnate at the base or forming a ring round the plumule or stem; about 8–9 mm. long, 2–2·5 mm. wide, deciduous at the joint.

Stem erect, terete, somewhat thickened at the nodes from the decurrent foot of the petiole, glabrous, deep shining green, ultimately shrubby; 1st, 2nd, and 3rd internodes each about 3 mm. long; 4th 3·25 mm.; 5th 9–10 mm.; 6th 21 mm.; 7th 13·5 mm.; 8th 8·5 mm.

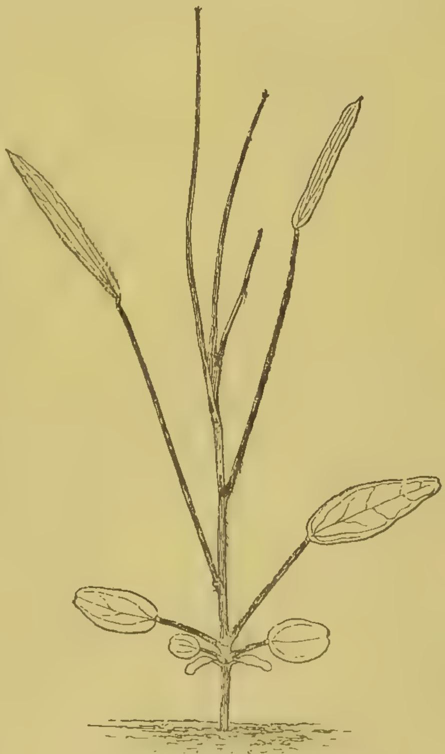

FIG. 262.—*Viminaria denudata.* Half nat. size.

Leaves simple or compound (uni- to tri-foliolate), cauline, alternate, stipulate, petiolate, glabrous, three- to five-nerved at or close to the base, alternately incurvinerved upwards, obscurely reticulate, deep green above, paler beneath or glaucous; stipules small, subulate, subfleshy, glabrous, partly or almost wholly adnate to the stem and foot of the petiole; petioles subterete, shallowly grooved above in the lower leaves and short, but gradually attaining a considerable length (6–11·4 cm.) about the fourth and fifth leaf and upwards, nearly or quite terete, slightly angled or striate, bright green, glabrous, articulated to the stem with a foot-like process and also with the lamina.

No. 1. Small, oval, obtuse, emarginate, trinerved at the base.

No. 2. Similar, somewhat larger, and emarginate at both ends.

No. 3. Oblong, obtuse and slightly notched at both ends, three- or faintly five-nerved.

No. 4. Lanceolate, obtuse, cuspidate, faintly five-nerved.

No. 5. Linear-lanceolate, suddenly narrowed to a subulate acute tip, trinerved.

No. 6. Linear, otherwise as No. 5.

No. 7. Reduced to a petiole tipped with three small, subulate, acute points or processes, diverging above the middle and corresponding to three reduced leaflets.

Nos. 8–10. Similar.

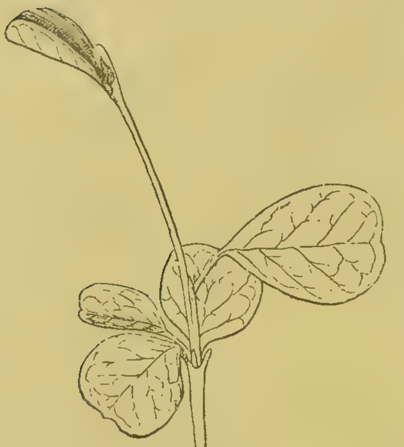

Fig. 263.—*Bossiæa linophylla*, × 3.

Tribe Genisteæ.

Bossiæa linophylla, *R. Br.* (fig. 263).

Hypocotyl erect, terete, glabrous, tapering upwards, green at first, soon becoming stained with red, 6–14 mm. above the soil.

Cotyledons oblong, obtuse, entire, petiolate, slightly indented on one side a little above the middle, fleshy, deep green and shining above, glaucous beneath; lamina 3·5–4·5 mm. long, 2 mm. wide; petiole grooved above, convex on the back, perfoliate at the base, 1–1·25 mm. long.

Stem erect, terete, glabrous, pale green, ultimately woody; 1st internode 5–13·5 mm. long; 2nd and 3rd undeveloped; 4th 2·5–7 mm.; 5th 4–8 mm.

Leaves simple, entire or merely slightly emarginate, cauline, alternate (first three on same level), stipulate, petiolate, alternately and ascendingly penninerved, reticulate, glabrous, deep subglaucous-green above, glaucous beneath; petioles biconvex or subterete (those of first pair flattened), glabrous, green or slightly tinged with red, very short, especially those of the first pair of leaves; stipules small, subulate, acute, glabrous, green, absent from the third leaf or amalgamated with those of the first two leaves.

Nos. 1 and 2. Opposite, broadly obovate, shallowly and broadly emarginate, with a small deltoid tooth in the sinus.

No. 3. On the same level as the first two, but at right angles to them, with a slightly longer petiole and somewhat narrower, but otherwise similar.

Nos. 4–6. Similar both in shape and size, or somewhat larger and having longer stipules.

Bossiæa rufa, *R. Br.*

Hypocotyl as in last species but only 2–3 mm. above ground.

Cotyledons very similar to those of last species; lamina 5 mm. long, 2·25 mm. wide; petiole ·5 mm. long.

Stem as in last species; 1st internode 6 mm. long; 2nd 1 cm.; 3rd 1·3 cm.

Leaves.—Nos. 1 and 2. Opposite, oval, entire, apiculate, deep glaucous-green above, glaucous beneath.

Nos. 3–5. Alternate, obovate, apiculate, coloured like the first two.

Hovea longifolia, *R. Br.*

Hypocotyl 1·5–2 cm. long, 1–2 mm. thick, firm, terete, glabrous, colourless near the base, bright green under the cotyledons.

Cotyledons sessile, inserted above the free base, ·75 cm. long, ·5 cm. broad, 1 mm. thick, oblong, split at base, rounded and reflexed at apex, obscurely nerved, glabrous, light green, not very persistent.

Stem terete, firm, tomentose, bright green; 1st internode 1–2 cm. long, 1 mm. thick; 2nd and 3rd longer or shorter.

Leaves simple, entire, at least in early stages, cauline, alternate (first pair opposite), stipulate, very shortly petiolate, alternately and ascendingly penninerved, reticulate, a few hairs on both surfaces, at least when young, deep green above, paler or glaucous beneath; stipules small, subulate, inconspicuous.

Nos. 1 and 2. Nearly opposite, shortly stalked, 1·5 cm. long, and as broad, suborbicular or broadly ovate, retuse, with sunk pinnate nervation and beautifully reticulate, thin, with a few hairs scattered over both surfaces, dark green above, almost glaucous beneath.

Nos. 3 and 4. Nearly opposite, more elongated, ovate, pubescent.

Nos. 5 and 6. Tomentose when young.

Goodia lotifolia, *Salisb.*

Primary root very long, tapering finely, with lateral rootlets on which are a few ovoid fleshy tubercles.

Hypocotyl suffrutescent, erect, terete, glabrous, about 9 mm. above ground, 1·5 mm. thick, proportionately very succulent and thick shortly after germination.

Cotyledons thick, fleshy, subobovate-oblong, shortly petiolate, flat on the upper faces, with a cavity at the base, in which the young plumule was at first protected, convex on the back, with a median longitudinal ridge and two furrows, purplish-green, 6·5 mm. long, 3 mm. broad.

Stem erect, terete, suffrutescent, glabrous, pale green, and suffused with red at the base; 1st internode 3·35 cm. long; 2nd undeveloped; 3rd 1·6 cm.; 4th 8 mm.; 5th 1·3 cm.; 6th 1·35 cm.

Leaves compound, pinnately trifoliolate (first two unifoliolate resembling foliaceous cotyledons), alternate (first three on the same level or almost so in a great number of specimens), stipulate, petiolate, glabrous, deep green above, paler and subglaucous beneath, folding downwards at night as well as the leaflets; petiole terete, smooth, reddish, with a green pulvinus at the base; stipules subulate, attenuate, free.

Nos. 1 and 2. Unifoliolate; leaflets large, broadly ovate, obtuse or minutely emarginate, subcordate at the base, otherwise entire.

No. 3. Pinnately trifoliolate; leaflets obovate, minutely apiculate, otherwise entire, with a small pulvinus, and articulated with the rachis, folding downwards at night; rachis between the leaflets, 4 mm. long.

Nos. 4–9. Similar, but successively larger.

Note.—The leaflets ultimately become broadest about the middle, and consequently change gradually from obovate to elliptic.

Crotalaria quinquefolia, *L.*

Hypocotyl erect, terete, downy, 1–1·5 cm. long, light green or colourless.

Cotyledons oblong, falcate, obtuse, fleshy, shortly petiolate glabrous, except on the petioles, dark green, indistinctly trinerved.

Stem erect, terete, herbaceous, downy; 1st internode 4–7 mm. ong; 2nd 6–10 mm.

First leaves simple, cauline, alternate, obovate, obtuse, almost trilobed, downy, especially on the under side, finely ciliated, light green, petiolate, exstipulate, alternately pinnatinerved; petiole terete, downy.

Crotalaria sp.

Hypocotyl more slender than in preceding species, 4–8 mm. long, and reddish-green.

Cotyledons rather narrower and constricted about the middle, with a prominent midrib only.

Stem, 1st internode from 1·5–2 cm. long; 2nd internode only 2–4 mm.

Leaves opposite, acutely ovate, ciliate; hairy petioles about half the length of the leaf, exstipulate, slightly drooping.

Lupinus arboreus, *Sims.* (fig. 264).

Primary root a rather long, fleshy, colourless tap-root, with a few thick lateral rootlets, often tuberculated.

Hypocotyl 2–3 cm. long, 2–3 mm. thick, fleshy, terete with horizontal ridges or articulations, shining white where covered by soil, purplish-red above, quite glabrous.

Cotyledons equal, or nearly so, including the petiole 1·5–2 cm. long, 6–8 mm. broad, oblong, oblique at the base, rounded at the apex, entire, obscurely penninerved, fleshy or succulent, glabrous and dark green on

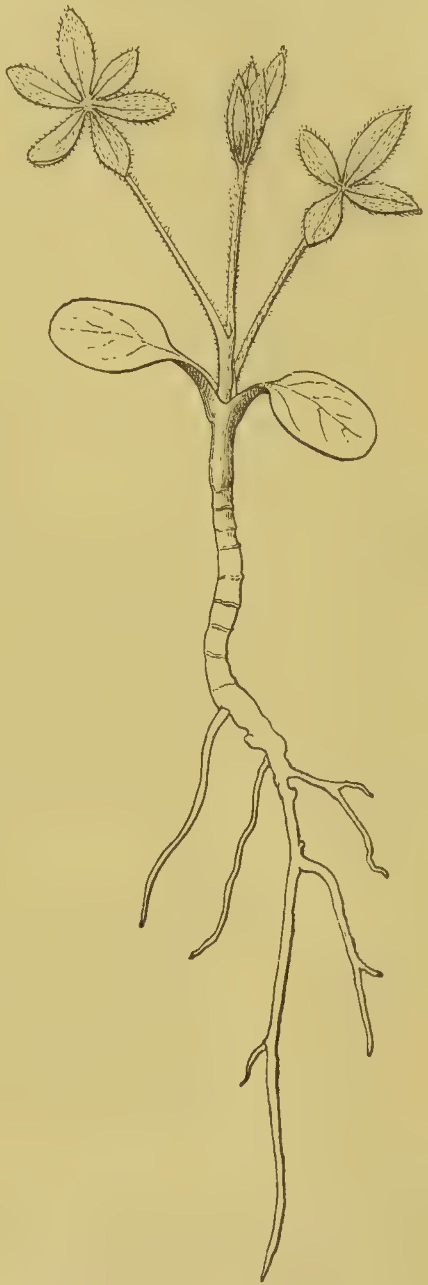

Fig. 264.—*Lupinus arboreus.* Nat. size.

both sides, somewhat persistent; petiole glabrous, 1·5 mm. thick, channelled, purplish-red.

Stem very short, ultimately elongated and woody.

Leaves digitate, radical and cauline, alternate, stipulate, petiolate, pubescent, with a distinct midrib and other inconspicuous venation; petiole semiterete, channelled above, sheathing at the base by its adnate stipules, which have a subulate, free point.

Nos. 1–3. With reddish, pubescent petiole, 2, 4, or more cm. long, 1–2 mm. thick, and sheathing at base, with a digitate lamina composed of four, six, or more obovate-lanceolate, acute, pubescent, deep green leaflets, ·5–1·5 cm. or more long, by 3–5 or more mm. broad.

Lupinus micranthus, *Douglas*.

Primary root similar to that of L. arboreus.

Hypocotyl erect, terete, very short, glabrous, 4–5 mm. long.

Cotyledons very similar to those of L. arboreus, with a flexuose midrib and alternate, flexuose, and anastomosing lateral veins, all sunk in the tissue, deep opaque green above, paler beneath; lamina 9–11 mm. long, 6–7 mm. broad; petiole semiterete, channelled above, dilated and perfoliate at the base.

Stem annual, developed when about to flower.

Leaves glabrous above or nearly so, ciliate at the margin, silky beneath, thick and subfleshy; petiole terete, slightly flattened on the upper side, dilated and amplexicaul at the base, slightly hairy; stipules, in the seedling at least, adnate to the petiole for two-thirds their length, with narrowly subulate, obtuse, or subacute free points and hairy where free.

No. 1. Digitate, with three linear, obtuse leaflets, involute at the sides so as to be deeply channelled, as are all the others, at any rate up to the seventh.

Nos. 2 and 3. With four linear, cuspidate leaflets.

No. 4. With five acute or aristate leaflets.

No. 5. With six acute leaflets.

Nos. 6 and 7. Similar.

Lupinus sulphureus, *Douglas* (fig. 265).

Hypocotyl erect, terete, glabrous, 2–2·5 cm. long, light green.

Cotyledons suborbicular, thick, fleshy, connate at the base, slightly denticulate, glabrous, dark green, very indistinctly tri-nerved.

Stem with primary internodes undeveloped.

First leaves compound, digitate, five-foliolate, petiolate, with rather long petioles, alternate, with small stipules; leaflets simple, entire, lanceolate, acute, ciliate, hairy, green, apparently one-nerved.

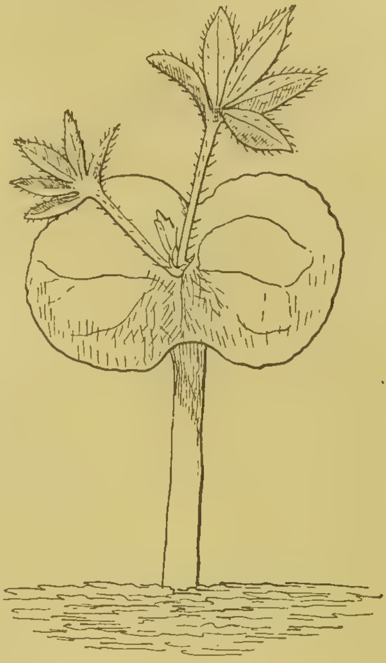

Fig. 265.—*Lupinus sulphureus.* Nat. size.

Laburnum vulgare, *Griseb.* (fig. 266).

Fruit a legume, linear, acute, stipitate, much compressed laterally and torulose when mature, irregularly veined longitudinally or subreticulate, thickened at the sutures, silky, dehiscing longitudinally by both sutures and somewhat twisted, many-seeded.

Seed persisting for some time on the placentas of the unopened or opened legume, horizontal, oblong, tumid, hooked at the upper end; seed-coat crustaceous or very hard; testa black or deep brown, shining; tegmen pale-coloured, membranous; chalaza below the middle; hilum near or at the middle; the micropyle above it on the ventral aspect.

Endosperm in the mature seed forming a thin layer surrounding the embryo, but much thicker at the sides, that is on the backs of the cotyledons, almost transparent or colourless when dry, and very hard, almost horny.

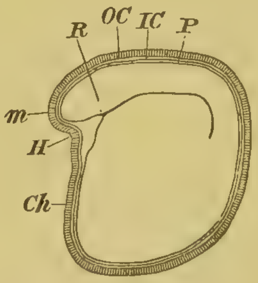

Fig. 266.—*Laburnum vulgare*, × 6. Longitudinal section of seed: *Ch*, chalaza; *H*, hilum; *m*, micropyle; *R*, radicle; *OC*, outer coat (testa); *IC*, inner coat (tegmen); *P*, endosperm.

Embryo comparatively very large, curved, fleshy, yellow; cotyledons oblong, subfalcate, obtuse, slightly notched or indented at about the middle on one edge, unequal at the base, with the larger auricle on the same side as the radicle, while the other side is cut away at the base owing to the shape of the seed, plano-convex, fleshy, each filling about half the interior of the seed, except that occupied by the radicle and endosperm, notched at one side owing to a mass of endosperm under the hilum, and also slightly to a thickening of the chalaza, accumbent, lying in the broader plane of the seed with their edges to the placenta ; radicle cylindrical-oblong, obtuse, passing round the upper end of the seed and pointing downwards to the micropyle on the ventral aspect, much shorter than the cotyledons.

Seedling (fig. 267).

Primary root tapering downwards, long, with a few lateral rootlets.

Hypocotyl erect, terete, very stout, slightly tapering upwards, passing suddenly below into the primary root, glabrous, pale green or stained with red, 1·3–2·5 cm. long.

Cotyledons broadly oblong, obtuse, entire, slightly falcate and shallowly indented on one side (by a thickening in the testa of the seed), entire, slightly asymmetrical at the base, on one side of which they are gradually tapered, and on the other truncate, owing to the position of the radicle in the seed, shortly petiolate, thick, fleshy, deep green, opaque, and obscurely trinerved at the base, glabrous ; lamina 1·4–1·5 cm. long, 7·75–8·25 mm. wide ; petiole deeply grooved above, convex on the back, about ·5 mm. long.

Stem erect, terete, silky, pale green or somewhat hoary, ultimately woody ; 1st internode 5–8 mm. long.

Leaves compound, digitately trifoliolate, cauline, alternate, stipulate, petiolate, silky on the under side with adpressed hairs, ciliate at the margin, glabrous above or nearly so ; leaflets closely and alternately penninerved, with the nerves branching and uniting within the margin, forming numerous reticulations ; stipules small, subulate, silky, at the very base of the petiole.

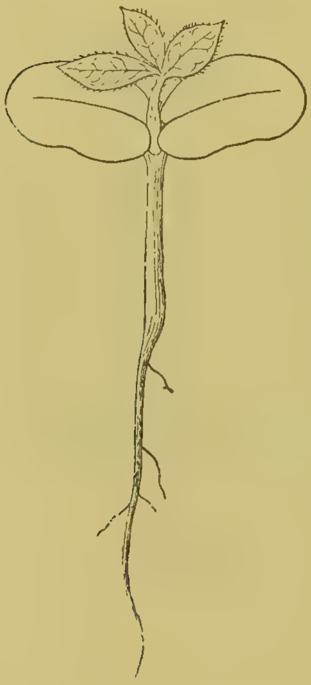

Fig. 267.
Laburnum vulgare.
Nat. size.

No. 1. Digitately trifoliolate ; lateral leaflets elliptic or ovate-elliptic, often, if not always, unequal in size with a difference varying from ·5–4 mm. in length, acute or cuspidate, shortly petiolate ; terminal leaflet lanceolate-elliptic, acute, longer and larger than the lateral ones, shortly petiolate.

Ultimate leaves digitately trifoliolate ; leaflets elliptic-lanceolate, cuspidate, narrowed to both ends, but especially to the base; lateral ones often slightly unequal in length; terminal one always the largest.

Retama Rœtam, *Webb et Berth.*

Hypocotyl erect, terete, glabrous, 4–4·5 cm. long, light green or colourless with a reddish tinge near the base.

Cotyledons oblong, obtuse, entire, shortly petiolate, thick, fleshy, glabrous, light green, indistinctly pinnatinerved like the leaves.

Stem erect, ribbed, herbaceous, hairy; 1st internode 2·5–2·6 cm. long; 2nd 5–7 mm.; 3rd 1·5–1·6 cm.; 4th 4–7 mm.

First leaves simple, entire, cauline, alternate, exstipulate, shortly petiolate or subsessile, oval-lanceolate, subacute, covered with long silky hairs which give it a white appearance, pinnatinerved.

Genista sp.

Hypocotyl erect, terete, glabrous, pale green, about 1·8–2·4 cm. long.

Cotyledons broadly oblong or oval, obtuse, entire, very shortly petiolate, showing a midrib but no other venation, horizontal on erect petioles, very slightly indented on one side, glabrous, light green; lamina 10·5 mm. long, 8 mm. wide; petiole erect, grooved above, ·5–1 mm. long.

Stem erect, terete, striate, hairy, pale green when young; 1st internode 17 mm. long; 2nd 5 mm.; 3rd 10·5 mm.; 4th 4 mm.; 5th 11·5 mm.

Leaves simple and compound, cauline, alternate, stipulate, with the first one petiolate, the others very shortly so or subsessile, alternately penninerved and obscurely reticulate, with the lateral nerves uniting at their apices to form a submarginal nerve, hairy above, silky beneath, with loosely adpressed whitish hairs, glaucous on both surfaces; petiole of first leaf subterete, channelled above, hairy, articulated with the stem; above the first leaf the petioles are reduced to a minimum and articulated with the stem; stipules small, tooth-like, ovate or subulate, obtuse, hairy.

No. 1. Digitately trifoliolate, with oblanceolate, acute leaflets, petiolate.

No. 2. Subsessile, digitately trifoliolate, and similar to the first.

Nos. 3–6. Oblong-elliptic, cuspidate, simple, entire, subsessile.

Ulex europæus, *L.* (fig. 268).

Primary root long, tapering, with lateral rootlets.

Hypocotyl glabrous, terete, green or whitish, 5 mm. to 1 cm. long.

Cotyledons oblong, obtuse, entire, fleshy, deep green, 8 mm. to 1·1 cm. long, 4–6 mm. broad.

Stem succulent, soon becoming shrubby, pale green, very hairy, ridged and furrowed; 1st and 2nd, or even to the 4th internode, undeveloped; 5th 2 mm. long; 6th undeveloped; 7th 2 mm. long; 8th 1 mm.; 9th 4 mm.: 10th 2 mm.; 11th–13th 3·25 mm.; 14th 2 mm.; 15th 3·25 mm.; 16th 3 mm.; 17th 2·5 mm.; 18th and 19th each 2 mm.; 20th 4 mm.; 21st and 22nd each 2·25 mm.; 23rd 1·75; 24th 1·5 mm. Different specimens vary in these lengths, but specimens that bear a close resemblance to one another fairly coincide in the lengths of the internodes.

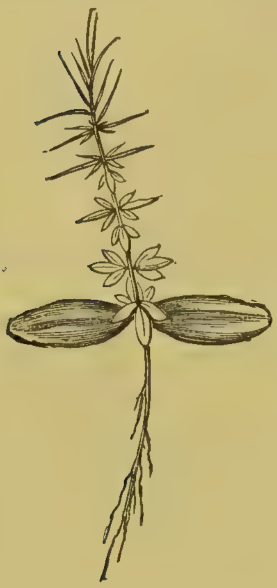

FIG. 268.
Ulex europæus.
Nat. size.

Leaves simple or digitately trifoliolate (in the seedling stage soon becoming simple), and ultimately reduced to spines, alternate, or the first four or six in opposite decussate pairs, hairy, deep green, or subglaucous on the upper surface; leaflets or simple leaf incurved at the margins and grooved or concave on the upper face, with the lower ones petiolate, the upper sessile; petioles grooved above, convex beneath.

First Specimen.—Leaves all simple, spathulate, with the first four in two opposite pairs.

Second Specimen.—1st pair linear-oblong, obtuse, simple.

2nd pair bifoliolate (one terminal and one lateral leaflet).

No. 5. Spathulate, entire.
No. 6. Trifoliolate.
No. 7. Spathulate.
No. 8. Bifoliolate.
No. 9. Bifoliolate.
No. 10. Spathulate.

Third Specimen.—Nos. 1–6. Trifoliolate; the first four in two opposite pairs.

Nos. 7–11. Spathulate.

Fourth Specimen.—Nos. 1 and 2. Trifoliolate, opposite.
Nos. 3 and 4. Spathulate, opposite.
No. 5. Bifoliolate, alternate.
No. 6. Spathulate.
Nos. 7 and 8. Bipartite.
Nos. 9–18. Spathulate or lanceolate, linear.

Fifth Specimen.—Nos. 1–6 in three opposite pairs. One of 1st pair bipartite, the other trifoliolate; of 2nd pair one is spathulate the other bipartite; 3rd pair trifoliolate.

No. 7. Tripartite.

No. 8. Bifid.

No. 9. Bipartite.

Nos. 10–14. Spathulate.

Nos. 15–25. Linear-lanceolate, spiny-pointed.

The branches are spinous from the first, their leaves spiny-pointed, and the secondary branches small and also spinous.

Spartocytisus nubigenus, *Webb et Berth.*, var. *roseus.*

Hypocotyl erect, terete, glabrous, 3–3·5 cm. long, dark brownish-red.

Cotyledons oblong, obtuse, entire, sessile, unequal, glabrous, brownish-red, indistinctly one-nerved.

Stem erect, striated, herbaceous, ultimately woody, covered with rather silky hairs; 1st internode 7–8 mm. long; 2nd rather shorter.

First leaves compound, trifoliolate, cauline, alternate, exstipulate, petiolate; leaflets linear-lanceolate, acute, entire, very shortly petiolulate or subsessile, hairy, light green, one-nerved; petioles long, hairy, slightly channelled on the upper side.

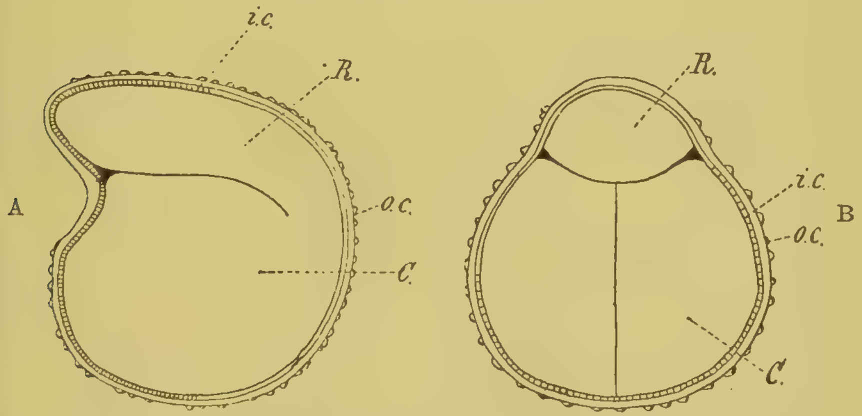

Fig. 269.—*Ononis altissima*, × 16. A, longitudinal section. B, transverse section: *R*, radicle; *C*, cotyledons; *o c*, outer coat of testa; *i c*, inner coat of testa.

Tribe Trifolieæ.

Ononis altissima, *Lam.* (fig. 269).

Seeds almost orbicular, with a prominent basal notch; testa tubercled, dark brown. Seed exalbuminous, 1·5–2 mm. in diameter.

Embryo curved or rounded on itself, filling the whole interior of the seed, yellowish-white.

Cotyledons oval or nearly round, fleshy, sessile with their edges to the hilum ; radicle accumbent on the edges of the cotyledons, angled, obtuse, rather longer than the cotyledons. Owing to the thickening of the testa near the basal notch there is probably a slight oblique emargination in the cotyledons.

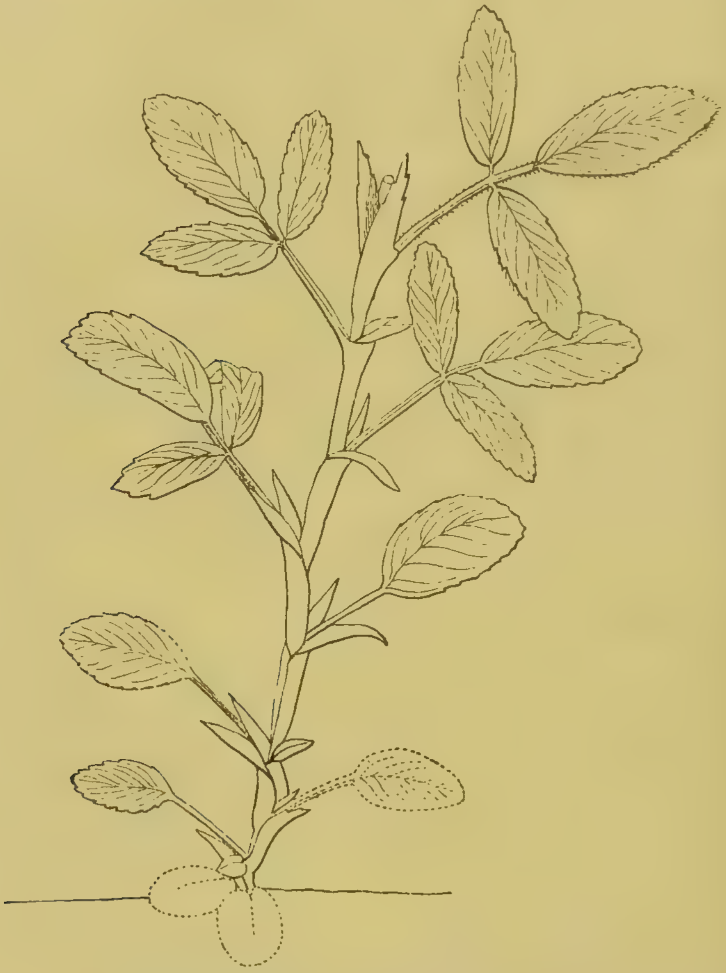

Fig. 270.—*Ononis Natrix*. Nat. size.

Ononis Natrix, *DC.* (fig. 270).

Hypocotyl subterranean.

Cotyledons shortly and broadly oblong, obtuse, densely hairy, 8·5 mm. long, 7 mm. broad ; petiole 1 mm. long.

Stem erect, terete, glandular-hairy, suffruticose at the base mostly covered by the large sheathing stipules ; 1st internode 2 mm. long ; 2nd 3·5 mm. ; 3rd 4·5 mm. ; 4th 7·5 mm. ; 5th 9 mm. ; 6th 8 mm. ; 7th 1·15 cm. ; 8th 1·15 cm. ; 9th 1·25 cm. ; 10th 1·05 cm.

Leaves compound, pinnately trifoliolate, cauline, alternate, stipulate, petiolate, glandular-hairy, smelling strongly; petioles channelled above, glandular-hairy; stipules adnate to the petioles for three-quarters their length, glandular-hairy, with ovate-subulate free points, entire or distantly serrate on the upper part of the stem.

Nos. 1–4. Unifoliolate; the three lower ovate, entire or slightly serrate towards the apex; the upper one ovate, oblong, cuspidate, serrulate with ascending parallel veins running into the serratures, as in all the other leaves.

No. 5. Pinnately trifoliolate; leaflets oblong, cuspidate, serrulate above the middle; terminal leaflet twice as broad as the lateral ones.

Nos. 6 and 7. Similar, but leaflets serrulate for three-quarters of their length.

Nos. 8–12. Leaflets more nearly equal in size and inclining to be oblong-elliptical.

Pocockia cretica, *Ser.*

Primary root long, tapering, fleshy, colourless, giving off numerous lateral rootlets which frequently have little white fleshy tubercles attached to them, annual.

Hypocotyl stout, tapering downwards, slightly wrinkled transversely, white, 1·2 cm. long, glabrous.

Cotyledons: lamina oblong, obtuse, articulated with its petiole, fleshy, bright green above, much paler beneath, 1·2 cm. long, 7 mm. broad, glabrous; petioles fleshy, slightly channelled above, dilated at the base and connate, 5 mm. long.

Stem herbaceous, annual.

Leaves compound, pinnately trifoliolate (first one simple or rather unifoliolate), radical and cauline, alternate, stipulate, petiolate, fleshy, glabrous, bright green above, glaucous or almost white beneath; petiole subterete, channelled, reddish and minutely pubescent above, pale green beneath, articulated above the stipules; stipules large, sheathing, adnate for two-thirds of their length to the petiole, with the upper third free, ovate, lacerated or deeply and sharply toothed, very pale, almost colourless.

No. 1. Unifoliolate; leaflet rotund, entire, or obsoletely dentate, bright green above with a crimson spot at its base, convex above, concave below and glaucous, articulated with the petiole.

No. 2, and all following it, pinnately trifoliolate; leaflets rotund-cuneate, emarginate with a tooth in the notch, obsoletely dentate, bright green above with a crimson spot at the base, glaucous beneath; terminal leaflet largest; rachis between the leaflets 4 mm. long.

Trigonella corniculata, *L.*

Primary root a short colourless tap-root with a few fibrous lateral rootlets.

Hypocotyl herbaceous, 2 cm. long, ·75 mm. thick, terete, glabrous, greenish-grey.

Cotyledons sessile and semi-amplexicaul, 1·25–1·5 cm. long, 3 mm. broad, linear-obovate, rounded at the apex, entire, with no visible nerves, glabrous, stout but not thick, light green.

Leaves pinnately trifoliolate (the first simple), cauline, alternate, stipulate, petiolate, alternately and ascendingly penninerved with the nerves running out into teeth, glabrous, pale or deep green above, paler beneath; petioles slender, glabrous; stipules small, adnate to the petiole with a free point.

No. 1. With a long slender petiole, simple; lamina 1 cm. long, and as broad; orbicular, mucronate, slightly denticulate, penninerved, glabrous, thin, uneven, yellowish-green above, slightly paler below; petiole about 2 cm. long, ·5 mm. broad, articulated near the apex, glabrous.

Trigonella Fœnum-græcum, *L.*

Hypocotyl much stouter than in T. corniculata, light green or colourless.

Cotyledons oval-oblong, obtuse, entire, fleshy, petiolate, glabrous, green, indistinctly pinnatinerved; petiole thick, short, channelled on the upper face, sheathing and connate at the base, suddenly becoming thin near the base of the leaf, so that the cotyledon appears articulated with it.

Stem erect, terete, glabrous; primary internodes but slightly developed.

Leaves trifoliolate, as in preceding species; leaflets obovate, shortly petiolulate, green, pinnatinerved.

No. 1. Simple, slightly toothed, obovate, shallowly emarginate; petiole hairy, deeply channelled on the upper side, becoming suddenly thin near the base of the lamina with which it is articulated; stipules thin, rather large, hairy, ending in a point.

Trigonella gladiata, *Stev.*

Primary root long and tapering, colourless, fleshy, throwing off numerous secondary rootlets towards its growing point, with occasionally small white fleshy tubercles, annual.

Hypocotyl subterranean, fleshy, tuberous, colourless, about 3 cm. long.

Cotyledons very similar to those of T. Fœnum-græcum, articulated with the petiole, 13 mm. long, 6 mm. broad; petiole 4 mm. long.

Stem herbaceous, annual, erect or flexuous, terete, pale green hairy; 1st internode 4·5 mm. long; 2nd 10 mm.; 3rd 5 mm.

Leaves as in other species, glabrous above, sparsely hairy beneath when young, glabrescent; petiole subterete, channelled above, articulated above the sheathing stipules, hairy, pale green slightly tinged above with red; stipules adnate to the petiole for two-thirds their length, hairy, pale green or almost colourless, with ovate, acuminate, free tips, entire.

No. 1. Unifoliolate; leaflet articulate with its petiole, rotund, entire, succulent like all the rest.

No. 2, and all succeeding. Pinnately trifoliolate; leaflets obovate-cuneate, emarginate, finely serrulate from the middle upwards, with numerous ascending, parallel nerves ending in the serratures, bright green above with a red midrib, glaucous beneath; middle leaflet largest; rachis between the leaflets 4 mm. long.

Medicago sativa, *L.*

Fruit a legume spirally twisted into two or three coils, several-seeded.

Seeds oblong with a notch near the hilum, exalbuminous, 2–3 mm. long; testa smooth, yellowish; hilum inconspicuous, near the micropyle.

Embryo curved or rounded on itself, filling the whole of the seed, colourless; cotyledons oblong with a tendency to become falcate, fleshy, entire, sessile, with their edges towards the hilum; radicle square or triangular, acute, considerably shorter than the cotyledons and accumbent.

M. lupulina, *L.*

Legume small, kidney-shaped, not spirally twisted, black.

Seed smaller than in M. sativa, rather more orbicular, 1·5–2·5 mm. in diameter.

Medicago orbicularis, *All.* (fig. 271).

In germination the spirally coiled legume splits readily along the dorsal suture, and the radicles of the various seeds seem all to make their exit along one side, while the cotyledons push out along the opposite side. By this means the fruit is effectually fixed to the soil while the embryos have no difficulty in getting out. The testa is, however, sometimes carried up by the cotyledons and splits irregularly as the cotyledons expand.

Twelve to sixteen seedlings from one fruit are not infrequent. A few instances occur (two to three out of fifty-six) where the radicle and cotyledons emerge together at one side of the fruit, and consequently stand out free from it. One instance occurred amongst fifty-six seedlings where the cotyledons got clear away from the fruit and seed, but the radicle failed to get out and consequently the seedling did not make the same progress as the rest and most likely perished. The cotyledons at this stage are oblong, obtuse, entire, petiolate, narrowed to the base, glabrous, somewhat fleshy, showing a midrib indistinctly, but no other venation, deep green above, paler beneath, but often suffused with purple. Hypocotyl glabrous, slender, purplish or ultimately green.

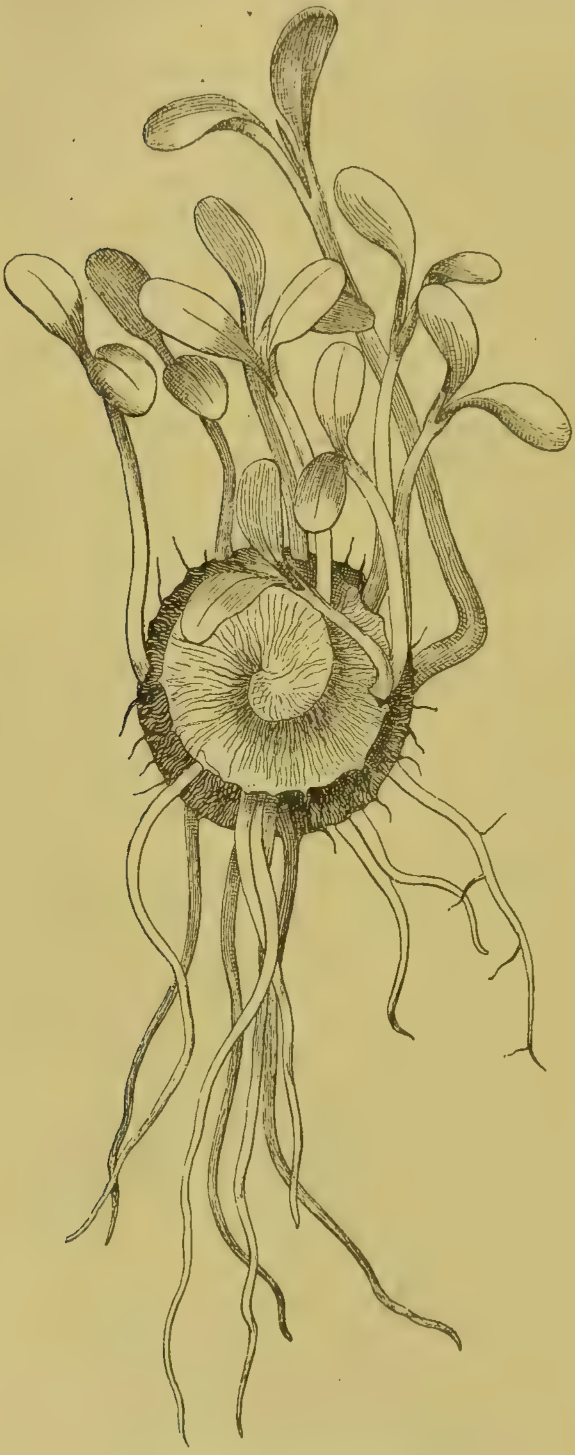

Fig. 271.—*Medicago orbicularis*, × 2.
Nine seedlings, all from one fruit.

Melilotus officinalis, *Willd.*

Primary root normal, slightly tuberculated, annual or biennial.

Hypocotyl erect, terete, glabrous, colourless when subterranean, red when rising out of the soil, tapering gradually into the root.

Cotyledons oblong, obtuse, fleshy, petiolate, glabrous, deep green; lamina 7 mm. long, 3·5 mm. broad; petiole articulated with the lamina, fleshy, channelled above, 1 mm. long.

Stem herbaceous, erect, terete, glabrous or thinly pubescent, green or purplish; 1st internode 2·4 cm. long; 2nd 2·7 cm.; 3rd 1·15 cm.

Leaves pinnately trifoliolate (1st unifoliolate), cauline, alternate, stipulate, petiolate, glabrous above, thinly pubescent on the under surface, deep or intensely glaucous-green above, glaucous beneath, alternately penninerved, with numerous, ascending, parallel, simple or forking veins; petioles trigonous, channelled on the upper side, thinly pubescent; stipules subulate, attenuate, entire, minutely ciliate.

No. 1. Unifoliolate, rotund, subemarginate, minutely notched at the base, obsoletely crenate, with the tips of the nerves depressed.

No. 2. Trifoliolate; terminal leaflet obovate, emarginate, obscurely toothed in the notch, obsoletely crenate; lateral leaflets obovate-oblong, otherwise like the terminal one.

Nos. 3–5. With rather longer, narrower, more evidently serrulate or denticulate leaflets.

Ultimate leaves pinnately trifoliolate; leaflets emarginate, toothed in the notch, denticulate; terminal one ovate, lateral ones oblong-elliptic.

Melilotus leucantha, *Koch*, closely resembles the preceding species but has rather larger cotyledons.

Trifolium Boissieri, *Guss.* (fig. 272).

Primary root long, tapering, with lateral rootlets and a few tubercles.

Hypocotyl tapering, fleshy, terete, colourless below the soil and purple above, glabrous, tapering insensibly into the root.

Cotyledons glabrous, fleshy; lamina oblong, obtuse, deep green, articulated with its petiole, 8 mm. long, 3·75 mm. broad; petioles dilated and connate at the base, channelled above, 2·5 mm. long.

Stem herbaceous, erect, flexuous, wiry and purple at the base, stouter upwards, angled, pale green, sparsely pubescent; 1st internode 1·2 cm. long; 2nd 1·2 cm.; 3rd 6 mm.

Leaves pinnately trifoliolate (No. 1 unifoliolate), cauline, stipulate, alternate, petiolate, minutely and sparsely pubescent, at least when young; stipules very shortly adnate to the petiole, one- or two-toothed at the basal posterior side, with a long, linear, subulate point.

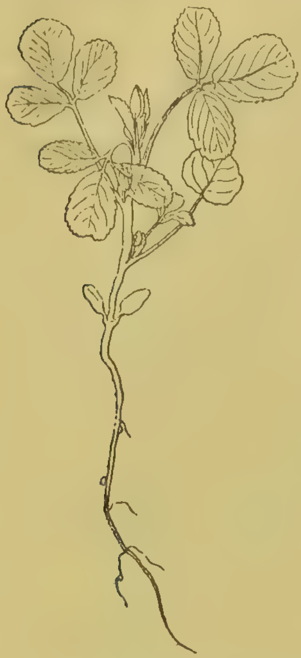

FIG. 272.
Trifolium Boissieri.
Half nat. size.

No. 1. Unifoliolate; leaflet large, transversely oval, apiculate, obsoletely crenulate; petiole like the others, subterete, channelled above, subamplexicaul at the base.

No. 2, and the rest. Pinnately trifoliolate; leaflets obovate, emarginate, with a tooth in the notch, serrulate, except on the basal third or half, rounded or emarginate at the base, deep green above and obscurely nerved, glaucous beneath, with parallel, ascending nerves running into the serratures; rachis between the lateral and terminal leaflets 3 mm. long.

Trifolium subterraneum, *L.*

Cotyledons oblong, obtuse, petiolate.

Leaves pinnately trifoliolate, radical and cauline, villous on both surfaces as well as the petiole, with ascending, parallel, simple, or forked veins.

No. 1. Unifoliolate, rotund, emarginate, toothed in the notch, obsoletely denticulate.

No. 2. Trifoliolate; leaflets rotund-obovate, otherwise as in No. 1.

Ultimate leaves pinnately trifoliolate; leaflets obovate, emarginate.

TRIBE LOTEÆ.

Anthyllis Vulneraria, *L.* (fig. 273).

Hypocotyl erect, terete, glabrous, pale green, 6 mm. to 1·7 cm. long.

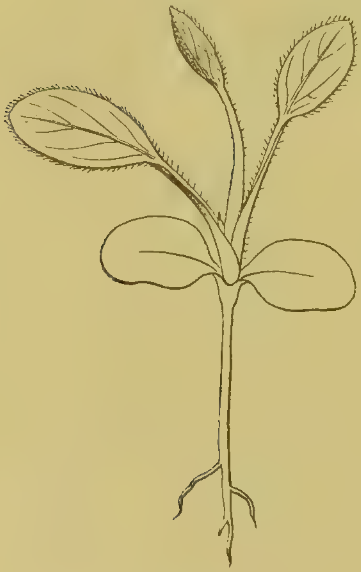

FIG. 273.—*Anthyllis Vulneraria.*
Nat. size.

Cotyledons large, fleshy, glabrous, obliquely oval, obtuse, suddenly narrowed at the base to a short petiole, 1–1·4 cm. long, 6–9·25 mm. wide; petiole shallowly grooved above, subperfoliate, about 3 mm. long.

Stem short, herbaceous.

Leaves compound (the first few are simple), radical, alternate, stipulate, petiolate, silky at the margin, otherwise glabrous, somewhat fleshy, thick, alternately and ascendingly penninerved, deep subglaucous-green; petioles deeply channelled above, gradually dilated to a wide amplexicaul base, hairy; stipules almost wholly adnate to the petiole (in young seedling) with small, subulate, brown free tips.

No. 1. Simple, entire, narrowly obovate-elliptic, minutely cuspidate

No. 2. Simple, oblong-elliptic, minutely cuspidate.

Lotus Tetragonolobus, *L.*

Primary root stout, fleshy, tapering downwards, with a few fleshy lateral rootlets, and comparatively large flesh-coloured tubercles.

Hypocotyl erect, terete, stout, colourless, glabrous, partly subterranean, 2·8–3·2 cm. long.

Cotyledons broadly oblong, cordate at the base, rounded at the apex, petiolate, fleshy, glabrous, five-nerved but very indistinctly and seen only on the under side, deep opaque green above, paler beneath and shining; lamina directed slightly to one side, 1·3–1·5 cm. long, 1–1·1 cm. wide; petiole very broad, grooved above, convex beneath, connate at the base, pale green almost colourless, minutely dotted with red, glabrous, articulated with the lamina, 5 mm. long, 3 mm. broad.

Stem herbaceous, annual, erect, dividing into four immediately above and between the cotyledons, pale green, densely hairy, almost villous; two branches take the lead and are the strongest; primary internode of the stronger pair of branches 1–1.4 cm. long; of the weaker pair 4–7 mm.

Leaves compound, cauline, alternate, stipulate, petiolate, somewhat hoary with pale-coloured or whitish hairs on both surfaces, glaucous-green above, paler beneath; leaflets alternately and ascendingly penninerved with the nerves discernible by transmitted light only, articulate with the petiole, the lateral one sessile, the terminal one shortly petiolulate; stipules foliaceous, obliquely triangular, obtuse, radiately nerved from the base, hairy on both surfaces like the leaves, sessile, not articulated with the petiole, but seated at its base and partly on the stem, semi-amplexicaul.

No. 1 on the larger branches. Ternate; terminal leaflet obovate, obtuse, entire or minutely emarginate, petiolulate; lateral leaflets sessile, obliquely obovate, unequal-sided, with the broadest half on the posterior side of the midrib, minutely cuspidate.

No. 2. Similar, but the terminal leaflet entire.

No. 1 on the smaller pair of branches similar to those of the larger pair of branches.

Note.—Out of one hundred and nine seedlings, seventy-six had the plumule divided into four stems or branches immediately it emerged from between the base of the cotyledons. The remaining thirty-three were either damaged or not sufficiently advanced to determine whether they would have two or four stems. There is every appearance, however, that it is a constant character of this species to have four instead of one primary stem.

Lotus peliorhynchus, *Hort.*

Hypocotyl erect, terete, 2–3·5 cm. long, greenish-brown, glabrous.

Cotyledons linear-oblong, entire, petiolate, obtuse, glabrous, greyish-green, with no apparent venation.

Stem erect, terete, herbaceous, downy, greyish; 1st internode 4–8 mm. long.

First leaves compound, digitate, shortly petiolate, downy; leaflets five, linear, acute, entire, sessile, greyish.

TRIBE GALEGEÆ.

Psoralea sp.

Hypocotyl erect, terete, glabrous, 1·5–2·5 cm. long, light green or colourless.

Cotyledons subfleshy, oblong, obtuse, falcate, petiolate, glabrous, light green, pinnatinerved; petioles 1·5–2 cm. long, channelled on the upper side.

Stem erect, square, herbaceous, with a few short silky hairs; 1st internode 1–1·2 cm. long.

First leaves simple, entire, cauline, opposite, ovate or cordate, obtuse, petiolate, stipulate, ciliate, covered with minute hairs, dark green, pinnatinerved, with the lateral veins very much branched; petiole 2–3 cm. long, covered with minute hairs, channelled on the upper side; stipules small, acute, entire, hairy.

Succeeding leaves are pinnate and alternate.

Indigofera australis, *Willd.* (fig. 274).

Hypocotyl erect, terete, suffruticose, 8–12 mm. long.

Cotyledons caducous.

Stem erect, terete, suffrutescent, pale green; 1st internode 1 cm. long; 2nd 1·8 cm.; 3rd 2 cm.; 4th 2·2 cm., minutely pubescent when young.

Leaves compound, imparipinnate (first two opposite and unifoliolate), alternate, stipulate, petiolate, deep green, glabrous, minutely pubescent at the margin, but all over when young; petioles subterete, channelled above as well as the rachis; stipules small, subulate, acute; leaflets stipellate.

Nos. 1 and 2. Opposite, unifoliolate; leaflets oblong-obovate, emarginate.

No. 3. Sometimes unifoliolate, but most frequently pinnately trifoliolate; terminal leaflet obovate, emarginate; lateral leaflets oval.

No. 4. Pinnately trifoliolate; leaflets oblong, emarginate; terminal one largest.

No. 5. Pinnately five-foliolate; lowest pair of leaflets oval, the rest larger and oblong.

No. 6. Pinnately seven-foliolate.

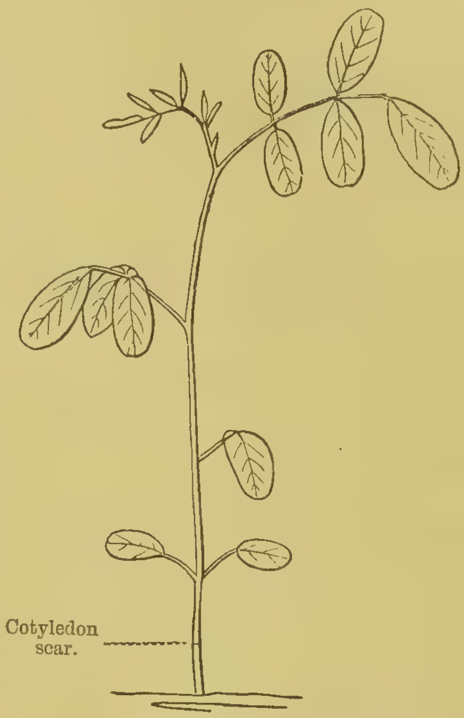

FIG. 274.—*Indigofera australis.* Two-thirds nat. size.

Galega officinalis, *L.*

Primary root long, tapering, fleshy, colourless, giving off numerous lateral rootlets, and furnished with numerous oblong-ovoid, fleshy tubercles.

Hypocotyl subsucculent at first, erect, terete, glabrous, mostly subterranean, tapering gradually into the root.

Cotyledons obovate-oblong, obtuse, subfleshy, tapering at the base to a short broad petiole, glabrous, spreading or arching, 1·4 cm. long including the petiole, 6 mm. broad.

Stem herbaceous, erect, terete at the base and angled upwards and striate, slightly thickened at the nodes, glabrous and shining, green suffused with purple, especially at the nodes; 1st internode 2 mm. long; 2nd 4 mm.; 3rd 1·2 cm.; 4th 1·2 cm.; 5th 1·3 cm.

Leaves imparipinnate (1st unifoliolate), cauline, alternate, stipulate, petiolate, glabrous, glaucous-green on both sides, paler beneath; petioles subterete, channelled above, sparsely pubescent; stipules free, subulate, attenuate, acute, pale green, glabrous, becoming broader upwards, and many-veined; leaflets entire with numerous parallel, ascending veins, forking towards the margin, obtuse or retuse and apiculate at the tip.

No. 1. Unifoliolate; lamina obovate-elliptic.

No. 2. Abruptly bifoliolate; terminal leaflet wanting; lateral leaflets oval or elliptic.

Nos. 3 and 4. Pinnately trifoliolate; leaflets elliptic.

Nos. 5 and 6. Pinnately five-foliolate; leaflets oblong-elliptic, upper three subapproximate.

Ultimate leaf of five or more pairs of leaflets and a terminal one; leaflets mostly opposite, ovate, obtuse, subcordate at the base, apiculate, glabrous, glaucous-green above, glaucous beneath; stipules ovate, acuminate.

Robinia Pseud-Acacia, *L.* (fig. 275).

Hypocotyl erect, terete, glabrous, pale green, slender, 1·6–2 cm. long.

Cotyledons oblong-oval, obtuse, entire, equal or very slightly unequal at the base, alternately incurvinerved, petiolate, thick with very obscure venation, glabrous, light green on both surfaces; lamina 8–9 mm. long, 5·5-6·5 mm. wide; petiole ascending, semiterete, channelled above, glabrous, 1 mm. long.

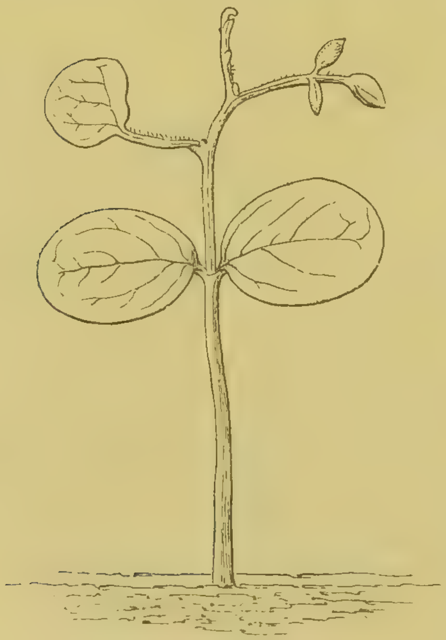

FIG. 275.—*Robinia Pseud-Acacia*, × 2.

Stem erect, terete, zigzag or flexuous, thinly pubescent in seedling stage with upwardly adpressed hairs, pale green, ultimately arborescent; 1st internode 5–7 mm. long, 2nd 2–3 mm.

Leaves compound (first one unifoliolate), imparipinnate, cauline, alternate, stipulate, petiolate, alternately and ascendingly penninerved and finely reticulate, thinly or more or less conspicuously pubescent on the margins and petioles, deep glaucous-green above, paler and glaucous beneath; leaflets entire, more or less conspicuously stipellate in the adult plant, articulated with the rachis; stipules small, subulate, inconspicuous or sometimes wanting; petioles subterete, shallowly channelled above, more or less pubescent, articulated with the stem and also with the leaflets.

No. 1. Rotund, obtuse, entire or shallowly emarginate (apparently deformed in specimen sketched).

No. 2. Pinnately trifoliolate; lateral leaflets opposite, elliptic, small, shortly petiolulate; terminal leaflet similar but much larger and with a longer petiolule.

Nos. 3–5. Pinnately trifoliolate, very similar to the 2nd. Branches in the axils of the first and second leaves similar to those of the primary stem.

Carmichælia pilosa, *Col.*

Hypocotyl erect, terete, slender, about 7 mm. long.

Cotyledons opposite or subalternate (perhaps accidental), oblong-spathulate, obtuse, entire, narrowed to the base.

Stem shrubby, slender, spreading, or diffuse and branching at the base, striate, terete at the base, and becoming dilated and flattened upward, deep brown and covered with an ascending, adpressed, white pubescence.

Leaves cauline, simple and ternately compound, alternate, stipulate, distichous, petiolate and petiolulate, pubescent on both surfaces as well as the petioles, becoming glabrous on the upper surface when old; pubescence adpressed upwards; petiole subterete, channelled above, about 5–8 mm. long, articulated at the base and apex below the leaf or leaflets; stipules small, scarious, and greyish, triangular or rounded and toothed, adpressed to the stem and petiole.

No. 1 to some indefinite number. Simple, obcordate, entire, articulate with the petiole, indistinctly penninerved.

Ultimately some leaves show a terminal with one lateral leaflet. Occasionally a few leaves have three leaflets; lateral ones similar but much smaller than the terminal one; petiolule of terminal leaflet about 2 mm. long; lateral ones much shorter. As the branch weakens towards the tip, the leaves are again reduced to a single leaflet.

Sesbania ægyptiaca, *Pers.* (fig. 276).

Fruit a legume, linear, terete or tetragonous, transversely septate between the seeds, dehiscing by two valves or not at all.

Seed transversely oblong, terete, obtuse at each end, smooth, shining, pale yellow; testa thin; hilum conspicuous above the middle on the ventral aspect, thickened, brown; chalaza ventral, towards the opposite end, but not quite basal.

Endosperm in the mature seed rather copious, cartilaginous, subtransparent, forming a thick layer at the back of each cotyledon, and a thin continuous layer at their edges and ends.

Embryo large, curved, nearly equal in length to the endosperm, central, conforming in general outline to that of the seed, pale yellow; cotyledons linear-oblong or oblong, obtuse, entire, slightly indented near the middle owing to a thickening at the hilum, and somewhat unequal at the base owing to the position of the radicle, rather thick, but flat, and both taken together presenting a somewhat rectangular appearance in transverse section; radicle stout, oblong, obtuse, accumbent and curved round to the micropyle at the base of the ventral aspect and outside the cotyledons.

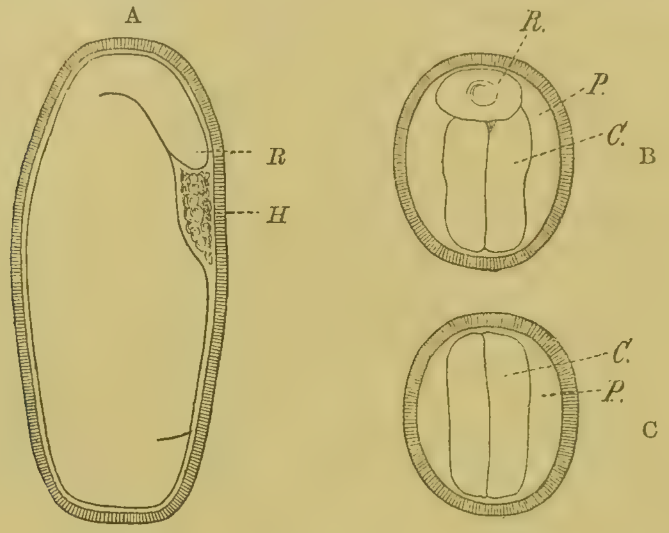

FIG. 276.—*Sesbania ægyptiaca*, × 13. A, longitudinal section of seed: *R*, radicle; *H*, hilum. B, transverse section of seed near the end containing the radicle, *R*: *P*, endosperm; *C*, cotyledons. C, transverse section of seed towards end opposite the radicle: *P*, endosperm; *C*, cotyledons.

Sesbania tomentosa, *Hook. et Arn.* (fig. 277).

Primary root long, nearly vertical, with many lateral branches thickened near their ends.

Hypocotyl erect, woody, 3–4 cm. long, about 1 mm. thick, terete near its base, ridged higher up by reason of the decurrent petioles of the cotyledons, densely covered with red dots especially below, otherwise of a paler green below.

Cotyledons subsessile, 1·5–2 cm. long, 8–10 mm. broad, unequal,[1] one oblong, the other oblong-obovate, entire, convex, obscurely penninerved, rather thick, glabrous, dull green above, paler beneath, not very persistent.

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[1] Inequality of cotyledons probably accidental.

Stem herbaceous, ultimately woody, erect, about 1 mm. thick; 1st internode 1·5 cm. long; 2nd and third shorter; otherwise much like the hypocotyl.

Leaves compound, abruptly pinnate (1st one entire), cauline, alternate, stipulate, petiolate, alternately incurvinerved and reticulate, pubescent in the young state, ultimately glabrous; leaflets oblong, entire, shortly petiolulate, opposite; stipules small, subulate, acute, caducous.

No. 1. Stipulate, petiolate, resembling the seed-leaves but larger, 3–3·5 cm. long, 1·25–1·5 cm. broad, oblong-obovate, acute at base, truncate and mucronate at apex, entire, irregularly penninerved and reticulately veined, with sunk midrib, flat, thin, glabrous.

No. 2. Abruptly pinnate, 3·5 cm. long, 2 cm. broad, with three pairs of subsessile, linear-oblong, oblique, mucronate leaflets, slightly pubescent beneath, ·75–1·25 cm. long and 2·5–5 mm. broad; rachis terminating in a long mucro, channelled, as well as the petiole.

Nos. 3 and 4. Similar, but with four pairs of leaflets.

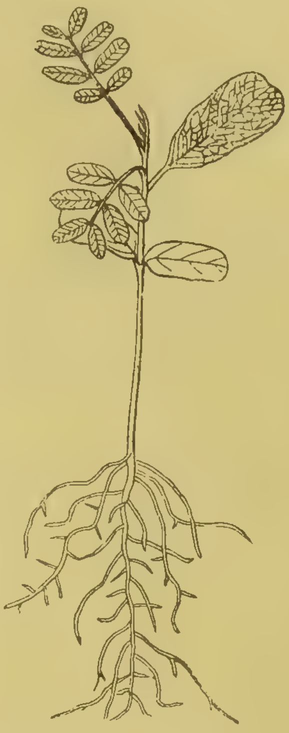
FIG. 277.
Sesbania tomentosa.
Half nat. size.

Youngest leaves pubescent on the under side of blade and petiole.

Sesbania grandiflora, *Poir.*

Hypocotyl erect, terete, glabrous, pale green, mottled with purple, 5·7 cm. long or shorter, 1·5–2 mm. thick.

Cotyledons petiolate, oblong, obtuse, entire, falcate, thick, fleshy, deep green, glabrous, 2·7 cm. long, 1·2 cm. broad; midrib sunk above, prominent beneath; petiole about 1 mm. long.

Stem erect, terete, glabrous, pale green, mottled with purple; 1st internode variable in length, 1–4 cm. long, 2 mm. thick; 2nd 2–5 mm. long.

Leaves cauline, alternate, stipulate, petiolate.

No. 1. Simple, articulated at the base of the petiole and at the base of the lamina; petiole terete, channelled above, purplish, 8·5 mm. long; lamina oblong-lanceolate, obtuse, mucronate, obscurely penninerved with ascending nerves, glabrous and deep green above, glabrous and glaucous beneath; stipules subulate, acute, falcate or recurved, reddish.

No. 2. Compound, abruptly pinnate, petiolate, glabrous; leaflets in four (sometimes five) pairs, oblong, obtuse, mucronate, penninerved, entire, deep green above, paler beneath, rather fleshy, opposite, petiolulate; petiolules slender, 1 mm. long, articulated at both ends; primary petiole and primary midrib subterete, channelled above, ending in a mucro between the last pair of leaflets; stipules as above.

No. 3. Abruptly pinnate, with five pairs of leaflets.

Swainsonia oncinotropis, *F. Muell.*

Hypocotyl 1 cm. long, 1 mm. thick, herbaceous, terete, glabrous, greyish-green.

Cotyledons subsessile, 1·5 cm. long, ·5 cm. broad, ·5 mm. thick, obovate-spathulate, rounded at apex, entire, obscurely nerved, glabrous, light green, rather persistent.

Stem herbaceous, terete, pubescent, light green; internodes 1–3 cm. long, 1 mm. thick.

Leaves compound, imparipinnate, cauline, alternate, stipulate, petiolate, alternately penninerved with ascending nerves, thin or membranous; leaflets entire, exstipellate; stipules herbaceous, generally broad at the base.

No. 1. Pinnately trifoliolate; leaflets ·5 cm. long, ·25 cm. broad, obcordate; terminal one twice as large, obcordate; petiole slender.

No. 2. Similar or imparipinnate, like the rest.

Calophaca, sp. nov.

Hypocotyl erect, terete, glabrous, soon becoming woody, with a dry, white appearance, 2–3 cm. above the soil, stout.

Cotyledons oblong, obtuse, falcate, with a shallow indentation or sinus on the contiguous sides, otherwise entire, petiolate, fleshy, with a few obscure, alternate, ascending nerves, deep opaque green above, lighter green beneath, glabrous, both rather conspicuously directed to one side of the plumule; lamina 1·5–1·7 cm. long, 7·5–8·5 mm. wide; petioles grooved above, convex on the back, glabrous, pale green, soon becoming pale or colourless, 4–5 mm. long.

Stem erect, terete, glandular-pubescent and hairy or villous, pale green, soon becoming woody and white; 1st internode 8 mm. long; 2nd about ·5 mm.; 3rd 3·5 mm.; 4th 3·5–4 mm.

Leaves compound, imparipinnate, cauline, alternate, stipulate, exstipellate, petiolate and shortly petiolulate, villous beneath and more or less dotted with sessile glands on the nerves, glaucous above.

paler beneath and glaucous; leaflets emarginate, with a tooth in the notch, or entire and cuspidate, with numerous alternate, ascending, pale-coloured nerves; stipules linear or linear-subulate, obtuse, acute, or acuminate, soft, pale green, glandular-pubescent and villous, fringed or ciliated with gland-tipped hairs, shortly adnate to the stem by one edge and also the base of the petiole, but mostly below the articulation; petioles terete, glandular-hairy and villous, tapering upwards from a stout articulated base.

Nos. 1–4. Pinnately trifoliolate; lateral leaflets narrowly obovate, obtuse, entire, minutely cuspidate; terminal leaflet larger and broader, obtuse or minutely cuspidate; all very shortly petiolulate.

Nos. 5–7. Pinnately five-foliolate; leaflets obovate, cuspidate or emarginate, with a tooth in the notch; terminal one largest.

Caragana arborescens, *Lam.*

Fruit a legume, cylindrical, sessile, terete or turgid, glabrous, pale green, or straw-coloured when mature, dehiscing elastically along both sutures and twisting longitudinally, glabrous internally; seeds many, or few by abortion.

Seed transversely oblong, rounded and obtuse at both ends, glabrous, shining, pale yellow; testa coriaceous; micropyle and hilum contiguous on the ventral aspect above the middle; raphe elongated, forming a deep green line; chalaza at the lower end very conspicuous and prominent in the young growing seed, but shrinking considerably and distinguishable in the mature seed by a dark spot.

Endosperm absent.

Embryo large and occupying the whole interior of the seed, green when mature; cotyledons oblong or oval in outline, plano-convex, and usually, if not always, unequal, and, together with the radicle, conforming in outline to the interior of the seed, entire at the apex, not auricled, but variously indented or impressed by the radicle according to its position, lying in the slightly broader plane of the seed, which is influenced by the shape of the legume, with their edges directly or obliquely to the placenta; radicle very short, obtuse, compressed or subterete according to position, accumbent or obliquely or wholly incumbent, very much shorter than the cotyledons, and only reaching from their upper and basal end to the micropyle near the upper end of the ventral aspect of the seed.

The different positions of the radicle are apparently due to there being no defined and allotted space for it; it is accommodated merely by being squeezed against the edges of both cotyledons, or the edge or the back of one, which is impressed by its outline accordingly.

Astragalus thianschanicus, *Regel* (fig. 278).

Primary root tapering downwards, flexuous, furnished with short lateral rootlets, and producing more or less numerous sessile, fleshy, tubercules ; sometimes the primary root is overpowered by strong lateral rootlets.

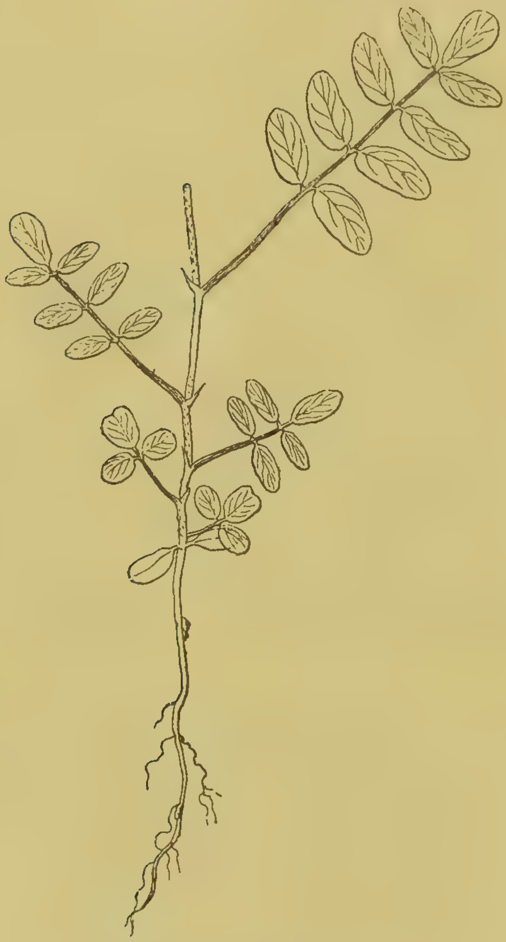

Fig. 278.—*Astragalus thianschanicus.* Half nat. size.

Hypocotyl erect, terete, glabrous, subterranean, colourless, 1·75 cm. long.

Cotyledons obliquely obovate, obtuse, glabrous, petiolate, subfleshy, deep subglaucous-green above, paler beneath ; lamina 9 mm. long, 5 mm. broad ; petiole subchannelled above, 3·5 mm. long, connate at the base and sheathing.

Stem erect or ascending, herbaceous, terete at the base, angular upwards, covered with a pale adpressed pubescence, ultimately glabrous or nearly so, and shining ; 1st internode 1·5 mm. long, sometimes longer ; 2nd 7 mm. ; 3rd 6·5 mm. ; 4th 1·2 cm. ; 5th 2·15 cm. ; 6th 3·2 cm. ; 7th 2·7 cm.

Leaves compound, imparipinnate, cauline, alternate, stipulate, petiolate, deep subglaucous-green and glabrous above, glaucous beneath and thinly pubescent with adpressed hairs ; petioles subterete, slightly channelled on the upper surface, pubescent, as well as the rachis ; stipules subulate, acuminate, slender, hyaline, with a few scattered hairs, connate by their posterior edges, and forming a kind of sheath opposite to the leaf in the seedling stage, sometimes, though rarely, splitting apart in the adult plant ; leaflets petiolulate.

No. 1. Trifoliolate ; lateral leaflets broadly oval, rounded at both ends ; terminal leaflet broadly oblong-obovate, emarginate.

No. 2. Sometimes trifoliolate, at other times five-foliolate.

No. 3. Five- or seven-foliolate ; leaflets broadly oblong, obtuse, sometimes minutely apiculate ; terminal one largest.

No. 4. Seven-foliolate.

No. 5. Nine-foliolate ; leaflets oblong, obtuse, subcordate at the base ; terminal leaflets broadest above the middle.

No. 6. Nine-foliolate.

No. 7. Fifteen-foliolate ; leaflets oblong, obtuse, apiculate, subcordate at the base ; those on the middle of the leaf largest.

No. 8. Seventeen-foliolate.

No. 9. Seventeen-foliolate.

Ultimate leaves with twenty-one to twenty-nine or more leaflets, which are oblong-lanceolate, minutely cuspidate, petiolulate, penninerved with alternate ascending nerves, deep green and glabrous above, glaucous and slightly pubescent with adpressed hairs beneath.

Astragalus sulcatus, *L.*

Primary root tapering, flexuose, reddish, giving off fleshy, colourless lateral rootlets, which soon become stouter than the primary one.

Hypocotyl wiry, terete, 2–6 mm. long.

Cotyledons oblong, obtuse, fleshy, most frequently oblique or falcate.

Stem undeveloped.

Leaves simple and compound, radical when described, alternate, somewhat silky with long whitish hairs, especially when young.

No. 1. Digitately trifoliolate ; leaflets oval—the terminal one largest and emarginate ; petiole subterete, channelled above, hairy ; petiolules ·5 mm. long ; stipules ovate or oblong, obtuse, hairy.

No. 2. Most frequently with the terminal leaflet only.

No. 3. Similar or digitately trifoliolate.

Intermediate forms are pinnately three- to five-foliolate ; terminal leaflet obovate or oblong, emarginate ; lateral leaflets obovate-oblong or oval, emarginate.

Ultimate leaves with many pairs of opposite (rarely alternate), linear-lanceolate, obtuse, emarginate, shortly petiolulate leaflets, glabrous, deep green ; stipules subulate, acute, thinly pubescent, small.

TRIBE HEDYSAREÆ.

Scorpiurus sulcata, *L.*

Primary root tapering downwards, with a few lateral rootlets.

Hypocotyl erect, terete, glabrous, about 1–1·25 mm. long, colourless below ground, yellowish-green above.

Cotyledons cylindrical, fleshy, from 4–4·5 mm. long, with a deep longitudinal furrow on the upper side, obtuse at the apex, dark green, one-nerved.

First leaves arising immediately between the cotyledons, oval or slightly obcordate, tapering to the base or subpetiolate, entire, subacute, with a few minute hairs on the edges, reticulate, dark green.

Coronilla juncea, *L.*

Hypocotyl erect, terete, glabrous, 1–2·2 cm. long, pale green or almost colourless.

Cotyledons fleshy, entire, obovate-oblong, petiolate, obtuse, glaucous-green, glabrous, indistinctly one-nerved.

Stem erect, terete, herbaceous, glabrous ; 1st internode 3–4 mm. long ; 2nd considerably shorter.

Leaves cauline, alternate.

No. 1. Simple, obovate, emarginate, obtuse, petiolate, stipulate, glabrous, light green, pinnatinerved.

No. 2. Compound, digitately trifoliolate ; leaflets oblong or slightly obovate, obtuse or sometimes subacute, opposite, sessile ; sometimes the first leaf is similar to the second.

Ornithopus repandus, *Lam.*

Primary root annual, long, slender, thread-like, with a few lateral rootlets, and numerous ovoid, fleshy tubercles.

Hypocotyl tapering downwards, terete, glabrous, colourless at base and brownish upwards, 2 cm. long.

Cotyledons foliaceous, fleshy, spathulate, oblong, obtuse, tapering into a short petiole, glabrous, deep green, 2·7 cm. long including the short petiole, 8 mm. broad.

Stem annual, slender, erect (at least when young), terete, glabrous, pale green ; 1st internode 2·2 cm. long ; 2nd 1·8 cm.

Leaves compound, digitately trifoliolate (first leaf unifoliolate), cauline, alternate, stipulate, sessile, glabrous, deep subglaucous-green, succulent; stipules subulate, subacute, connate two-thirds of their length on the side of the stem opposite to the leaf.

No. 1. Oblong, obtuse, entire, minutely apiculate, 2·4 cm. long, 1·2 cm. broad.

No. 2. Digitately trifoliolate; lateral leaflets sessile, rotund, minutely apiculate, 3 mm. long, 4 mm. broad; terminal leaflet large, rotund, elliptic, obtuse, 1·8 cm. long, 1·4 cm. broad.

Branches from axils of cotyledons similar to the stem; 1st and 2nd leaves also precisely the same.

Hedysarum denticulatum, *Regel* (fig. 279).

Fig. 1 shows the embryo germinating and splitting open the pericarp of a segment of the fruit. The radicle has pierced the lower valve of the pericarp.

Fig. 2. A case in which two segments have remained united. One embryo is dead; the other has forced open the pericarp of both segments, and its radicle has pierced the lower valve, a frequent occurrence.

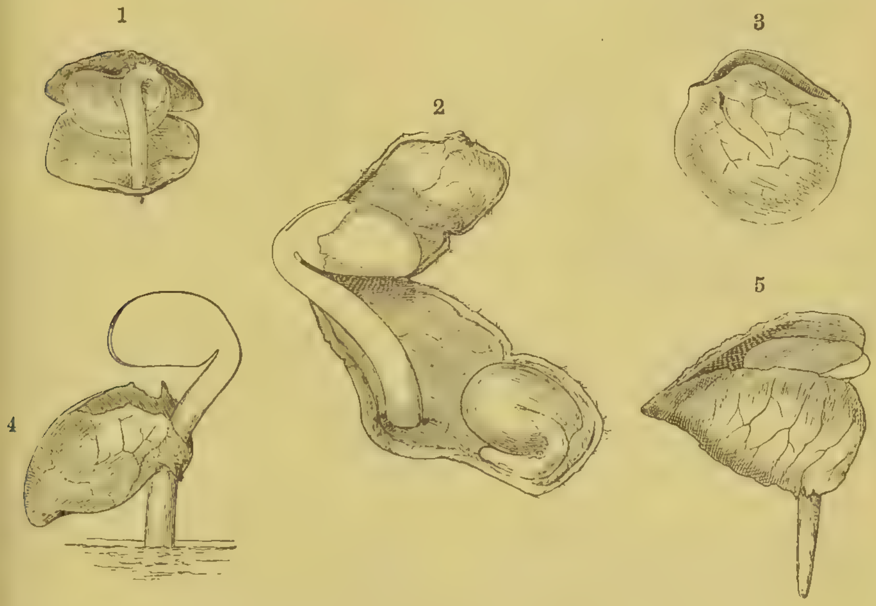

Fig. 279.—*Hedysarum denticulatum*, × 2½.

Fig. 3. Another segment of the fruit where the radicle has already advanced considerably through the wall; the two halves of the fruit have just commenced to split open.

Fig. 4. Another mode of germination similar to what occurs in

H. coronarium, the radicle emerging at one side of the fruit and the cotyledons at the other; cotyledons at this stage oblong, obtuse, entire. One day after germination.

Fig. 5 shows the ragged margin of the fissure made by the radicle through the walls of the fruit during germination.

Hedysarum coronarium, *L.* (fig. 280).

Legume linear or oblong-linear, much compressed laterally, constricted between each seed, and consequently moniliform, covered all over with short, stout, straight or hooked bristles, and having the edges of both ventral and dorsal sutures produced into revolute or hooked teeth, many-celled by the constrictions between each seed, and falling into separate, indehiscent pieces each containing a seed.

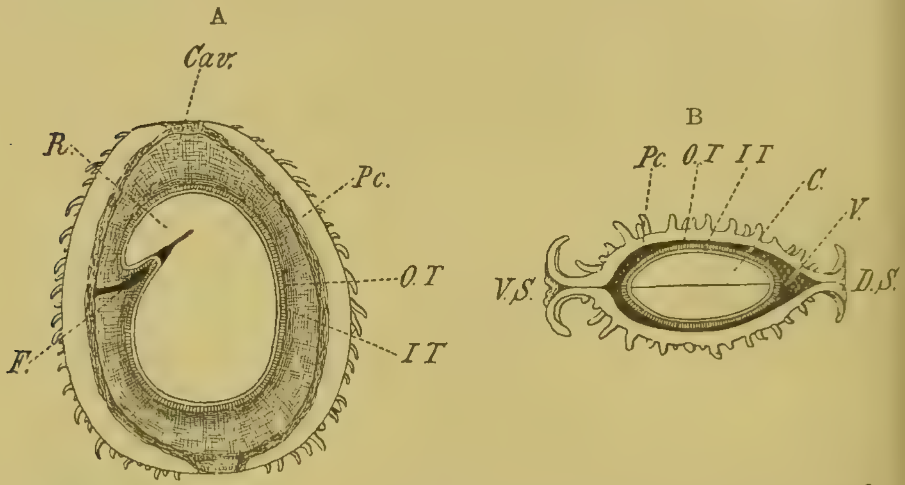

FIG. 280.—*Hedysarum coronarium*, × 6. A, longitudinal section of seed: *Cav*, cavity of the legume, and the only part where the internal cavity is nearly but not quite continuous; *Pc*, pericarp; *O T*, testa; *I T*, tegmen; *R*, radicle; *F*, funicle. B, transverse section of seed: *V S*, ventral suture; *D S*, dorsal suture; *Pc*, pericarp; *O T*, testa; *I T*, tegmen; *C*, cotyledon; *V*, empty space.

Seed reniform, somewhat laterally compressed in conformity with the interior of the segment of the fruit, thicker in the middle than at the sides and in transverse section accordingly elliptic, glabrous, obtuse at either end, pale yellow; testa pale brownish-yellow, rather thin, closely applied to the tegmen and embryo; tegmen thin, membranous, paler; hilum small, annular, situated in a small sinus formed by the curvature of the ovule about the middle of the ventral edge of the seed; micropyle and chalaza contiguous to, and on each side of, the hilum, with the former on the upper side, that is towards the apex of the ovary.

Endosperm absent.

Embryo transverse to the placenta, large and completely filling the seed, curved, pale yellow; cotyledons more or less distinctly obovate in outline, sessile, plano-convex, rounded at the apex, somewhat tapered towards the base, lying in the broader plane of the seed, with their edges to the placenta; radicle about half as long as the cotyledons, oblong, obtusely pointed at the upper end of the seed and consequently superior, but again curved downwards to the micropyle close to the hilum.

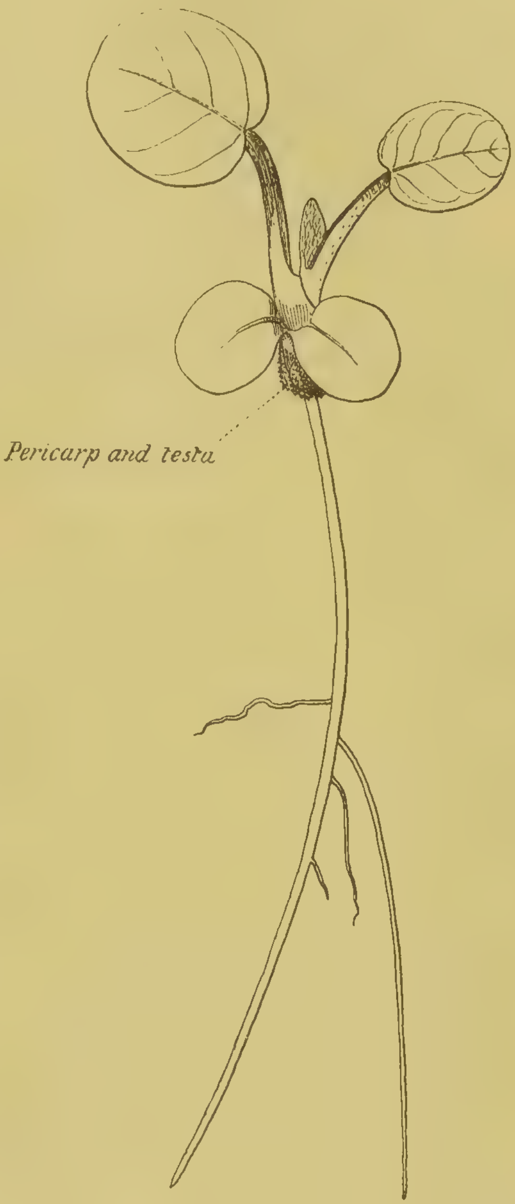

FIG. 281.—*Hedysarum coronarium.*
Nat. size.

Seedling (fig. 281).

Primary root long, fleshy, tapering slightly downwards, colourless, with a few lateral rootlets at irregular intervals.

Hypocotyl very short or soon indistinguishable from the root, emerging between the valves of the fruit, which remain attached to it long after germination.

Cotyledons oblique, broadly rotund-obovate, entire, fleshy, convex above, subrevolute at the margins, sessile, perfoliate at the base, forming a short turbinate tube, alternately penninerved with few incurved nerves, cartilaginous and subscabrous at the margin, 1–1·2 cm. long, 1–1·2 or 1·3 cm. broad.

Stem herbaceous, elongated when about to flower, arising from a perennial rootstock.

Leaves compound, radical and cauline, alternate, stipulate, petiolate (leaflets petiolulate, exstipellate), alternately and incurvi-penninerved, with the tips recurved and uniting, each with the one above it, glabrous and deep glaucous-green above, cartilaginous and ciliate at the margin, hairy beneath with adpressed hairs and paler; petioles channelled above, dilated at the base, hairy with adpressed hairs, semiterete in the seedling, angled and striate in the adult leaf; stipules scarious, adnate by one edge to the petiole, free only at the apex in the seedling stage, but having a subulate-ovate, acuminate free part in the adult plant, and one- to three-nerved or more.

No. 1. Orbicular, slightly cordate at the base, otherwise entire.

No. 2. Rotund-oblong, emarginate, cordate at the base.

No. 3. Broadly oval-oblong, cordate at the base, emarginate at the apex.

No. 4. Pinnately three- to five-foliolate; leaflets broadly oval or oblong-oval, slightly emarginate at the apex, terminal one the largest.

Radical leaves on the adult plant simple and cordate-orbicular, or much more frequently imparipinnate, with cordate, minutely cuspidate, entire, alternate or opposite pinnules; terminal one largest.

Hedysarum capitatum, *Desf.*

Hypocotyl erect or decumbent, terete, glabrous, pale green mottled with crimson, 8 mm. to 2 cm. above ground and projecting between the valves of the prickly seed-pod, which is often borne up by it.

Cotyledons large, foliaceous, glabrous, subcoriaceous or fleshy, rising above ground, petiolate; lamina obliquely obovate, obtuse, obscurely trinerved or binerved, entire, 1·4 cm. long, 1 cm. broad; petioles connate by their contiguous edges and lying to one side of the stem, broad, 2–4 mm. long.

Stem herbaceous, short, decumbent or suberect, pubescent, terete, slightly ridged, pale green, mottled with crimson; internodes irregular and frequently undeveloped.

Leaves compound, imparipinnate, cauline (at first appearing radical from the non-development of the internodes), alternate, stipulate, petiolate, glabrous above but pubescent or almost silky on the underside, and also on the rachis and petioles; petioles subterete, channelled above, dilated at the base; stipules adnate to the petiole for one-half their length, with ovate-subulate, acuminate points, crimson; leaflets shortly petiolulate.

No. 1. Five-foliolate; leaflets oblong, obtuse, apiculate, opposite.

No. 2. Seven-foliolate; leaflets opposite, oblong-oval, obtuse, apiculate.

No. 3. Ten-foliolate; leaflets alternate; lower obovate, small; upper larger, oblong, obtuse, apiculate.

No. 4. Thirteen-foliolate; leaflets opposite, oval, obtuse, apiculate.

No. 5. Fifteen-foliolate, otherwise like the last.

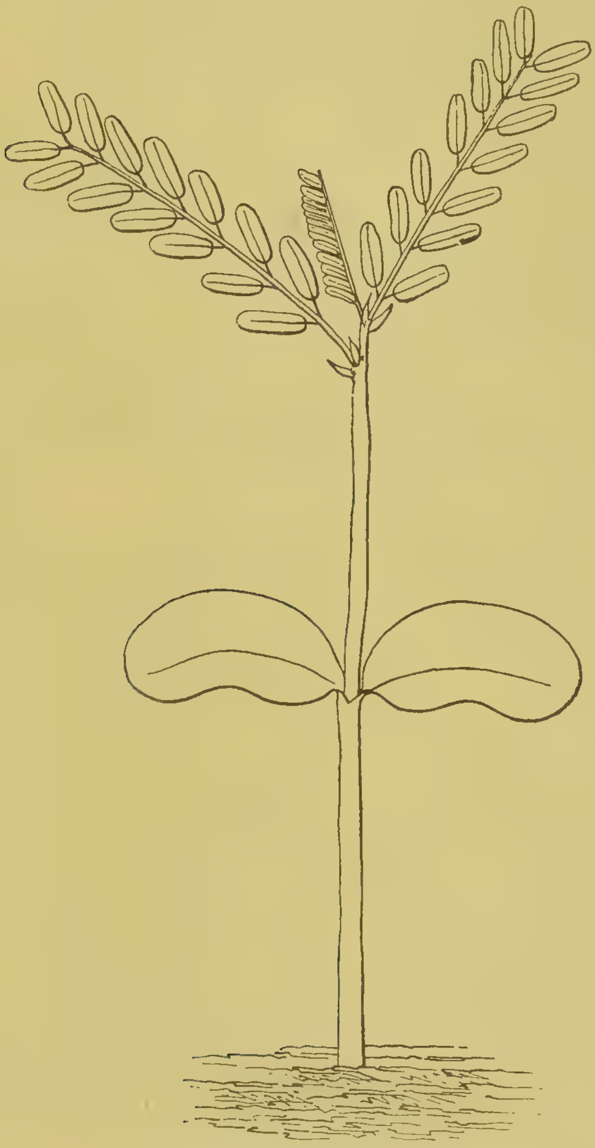

FIG. 282.—*Æschynomene aspera*, × 2.

Æschynomene aspera, *L.* (fig. 282).

Hypocotyl erect, terete, glabrous, 1·5–2 cm. long light green or colourless.

Cotyledons oblong, falcate, obtuse, fleshy, sessile, glabrous, light green, one-nerved.

Stem erect, terete, herbaceous, ultimately woody, light green, glabrous.

First leaves compound, abruptly pinnate, petiolate, alternate, stipulate; leaflets entire, oblong, obtuse, shortly petiolulate, opposite, from seven to nine in number; stipules ovate-subulate, acute, rather broad at the base and tapering to a sharp point.

Desmodium canadense, *DC.*

Germination.—The radicle emerges at the dorsal suture of the fruit, or breaks through the side walls. It fixes itself in the ground, and the lengthening hypocotyl generally carries the lomentum and seed up with it. All the coverings, however, finally drop off, leaving the seedling free. Where the radicle pierces the sides of the lomentum the latter is fixed to the soil. The cotyledons on becoming free are ovate-oblong, obtuse, subfalcate, or rounded on the upper edge and with a shallow sinus on the lower edge, subfleshy, pale yellowish-green, shining, glabrous.

Lourea Vespertilionis, *Desv.* (fig. 283).

Hypocotyl terete, pubescent, pale green, 2–4 mm. above soil.

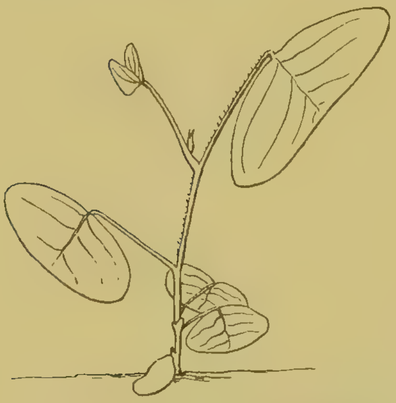

Fig. 283.—*Lourea Vespertilionis.* Nat. size.

Cotyledons shortly oblong, falcate, or subreniform, pubescent on both sides, pale green, shortly petiolate, 6 mm. long including the petiole, 3·5 mm. broad.

Stem erect, terete, herbaceous, pubescent, pale green; 1st internode 2·5 mm. long; 2nd 1·5 mm.; 3rd 4 mm.; 4th 9 mm.

Leaves compound (first ones unifoliolate, ultimately trifoliolate), cauline, alternate, stipulate, petiolate, pubescent on both surfaces and ciliate; petioles slender subterete or filiform, shallowly channelled on the upper side, pubescent, pale green; stipules subulate, acute, hairy; secondary stipules small, subulate, acute, pubescent.

Nos. 1–5. Unifoliolate; 1st leaflet transversely oval, penninerved, 4 mm. long, 1 cm. broad.

No. 2. Transversely oblong, penninerved and closely reticulate with reddish veins.

Nos. 3 and 4. Similar but larger, pendent from an ascending petiole, with a rather stout pulvinus; leaflet of No. 4, 9·5 mm. long, 2·65 cm. broad.

Ultimate leaves uni- or tri-foliolate; terminal leaflet very broad and short, apiculate, falcate, trinerved and reticulate, bronze-green suffused with red and white along the principal nerves, thinly pubescent on both surfaces and covered with minute hooked hairs; lateral leaflets small, most frequently absent, their stipules being present or absent.

Lespedeza angustifolia, *Ell.*

Hypocotyl terete, pubescent, very short.

Cotyledons oblong, obtuse, fleshy, subfalcate, turned to one side, faintly trinerved, densely pubescent, sessile, 6 mm. long, 4·25 mm. road.

Stem herbaceous, ultimately shrubby, erect, terete, pale green, ultimately reddish or brown, densely covered with patent hairs; 1st internode 4·5 mm. long; 2nd 7 mm.; 3rd 1·5 cm.; 4th 2·9 cm.; 5th 1·8 cm.

Leaves compound, pinnately trifoliolate (1st unifoliolate), cauline, alternate, stipulate, petiolate, glabrous above, ciliate, thinly pubescent beneath; petioles slender, subterete, channelled above, hairy like the stem; stipules free, slender, subulate, acute, hairy, scarious, brownish; leaflets petiolulate, having a pulvinus and folding downwards at night.

No. 1. Unifoliolate; leaflet rotund, emarginate, shortly petiolulate, minutely apiculate, deep green.

No. 2. Pinnately trifoliolate; terminal leaflet rotund-obovate, emarginate; lateral leaflets oblong-obovate, emarginate, much smaller than the terminal one—all deep green.

No. 3. Pinnately trifoliolate, deep green; leaflets obovate, apiculate, more nearly equal than those of No. 2; rachis between the leaflets 1·5 mm. long; nerves of leaflets ascending, parallel, slightly forking and anastomosing upwards; pulvini prominent.

No. 4. Pinnately trifoliolate, pale green (because very young); terminal leaflet obovate, apiculate; lateral leaflets oblong-obovate, apiculate; pulvini prominent.

TRIBE VICIEÆ.

Lathyrus Nissolia, *L.* (fig. 284).

Primary root long, tapering, fleshy, colourless, with short, stout, fleshy lateral rootlets, and occasionally fleshy tubercles.

Hypocotyl subterranean, fleshy, colourless, very short (about 1·75 mm. long).

Cotyledons subterranean, plano-convex, fleshy, each occupying half the interior of the seed, unequal-sided, so that the petioles or point of attachment to the plumule are at one side, horizontal, rotund, about 2 mm. in diameter, yellow and wrinkled after germination; petioles unequal or the lower one undeveloped, while the upper one is developed and curved just as much as will allow the cotyledons to lie horizontally. The cotyledons do sometimes stand vertically on their edges and then both petioles are equally developed.

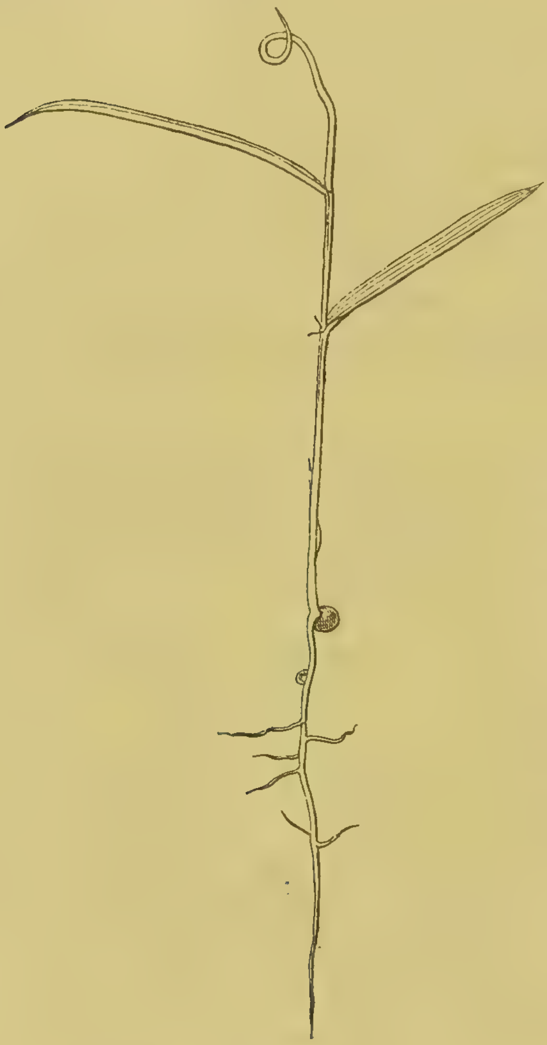

Fig. 284.—*Lathyrus Nissolia.* Nat. size.

Stem erect, but always hooked, curved or twisted at the tip, together with the youngest visible leaf, by which it hangs on to an object for support, with the internodes alternately flattened and angled on opposite sides, the angle running down the centre of the flattened face of the internode beneath it, pale green, glabrous; 1st internode 4·5 mm. long; 2nd 7·5 mm.; 3rd 1·9 cm.; 4th 1·5 cm.; 5th 1·35 cm.

Leaves simple, entire, cauline, alternate, distichous, stipulate, sessile and slightly decurrent, thinly and minutely ciliate at the margin, otherwise glabrous, light green; stipules small, subulate, acute, inserted where the leaf is free from the stem, except in the case of the first two scale-like leaves, where they are seated above the base, or may be altogether inconspicuous in the first.

Nos. 1 and 2. Small, subulate, acute, scale-like and adpressed to the stem, carinate.

Nos. 3–6. Linear acute or acuminate, five-nerved, convolute at first and rolled round the growing point, gradually becoming nearly or quite flat.

Lathyrus articulatus, *L.*

Primary root very similar to that of L. Nissolia.

Hypocotyl undeveloped or scarcely elongated.

Cotyledons rotund-obovate, very similar to those of L. Nissolia.

Stem herbaceous, annual, erect, ultimately climbing by means of its leaves, tetragonous at the base and narrowly winged upwards as in L. Nissolia, glabrous, pale glaucous-green; 1st internode 9·5 mm. long; 2nd 1·35 cm.; 3rd 2·9 cm.; 4th 3·12 cm.; 5th 4·5 cm.; the rest gradually longer.

Leaves very like those of L. Nissolia, glaucous, linear, acute, or afterwards acuminate and finally cirrhous at the apex, seven-nerved longitudinally (three strong and four intermediate nerves), slightly scabrous at the margin; stipules adnate to the sides of the leaves for some little distance above their insertion, with slender, subulate, free points, becoming triangular on the leaves a short way up the stem, and finally wholly adnate, obsolete, or inconspicuous.

No. 1. Subulate, acute, carinate, concave above, inconspicuously five-nerved.

No. 2. Ditto, but a little larger.

No. 3. Linear, acute, five-nerved.

No. 4. Linear, acuminate, trinerved with four intermediate, inconspicuous ones.

No. 5. Linear, produced at the apex into a short, simple cirrhus. Sometimes the 6th is the first to attain this stage, which represents apparently the ultimate form of the leaf.

Lathyrus Aphaca, *L.* (fig. 285).

Primary root long, tapering, fleshy, with numerous fleshy or succulent tubercles, and long lateral rootlets.

Hypocotyl undeveloped.

Cotyledons subterranean, fleshy, persistent, plano-convex or almost hemispherical, very unequal-sided by the petioles being attached to one corner, mostly vertical during and after germination, rarely horizontal, yellowish-white, afterwards more yellow and wrinkled; lamina truncate, 4 mm. long, 4·5 mm. wide; petioles very short, developed equally when the cotyledons are vertical, but when these are horizontal one petiole becomes longer than the other to allow the upper cotyledon to assume this position. There are intermediate positions where the cotyledons are oblique, and one petiole becomes somewhat elongated accordingly.

Stem annual, erect, tetragonous, with obtuse angles, glabrous, a pale glaucous-green above ground, while the subterranean part is colourless; 1st internode subterranean or partly so, 1–2 cm. long; 2nd 3·5–6 mm.; 3rd 7–10 mm.; the rest similarly short.

Leaves simple and compound, or reduced to scale-like organs or elongated, forming a slender, filiform, or obtusely-angled tendril, cauline, alternate, distichous, stipulate, petiolate or sessile, or reduced to a petiole, glabrous, glaucous-green; petiole of third and fourth leaf convex on the back, channelled above, and projecting beyond, or rather between, the leaflets in the form of a small, subulate, acute point; stipules of the first and second leaf subulate, acute, attached by one side for about one-third their length to the leaf, entire or furnished with an acute, ascending tooth on the side away from the leaf—those of the third and fourth leaf half-ovate or sagittate, acuminate, with one to two acute teeth at the lower angle on the posterior side, entire on the anterior side—those of the rest of the leaves large, foliaceous, performing the functions of leaves, deltoid, subhastate, cuspidate or apiculate, with one to two minute teeth at the base on each side, otherwise entire, glaucous, furnished with numerous parallel nerves that are directed first outward from the base, and upward, then somewhat inward, where they unite with those immediately above them close to the margin, while the few lowest are directed into basal teeth or angles, and are entire or forked; a branch from the lowest curved nerve is frequently directed straight into the tooth.

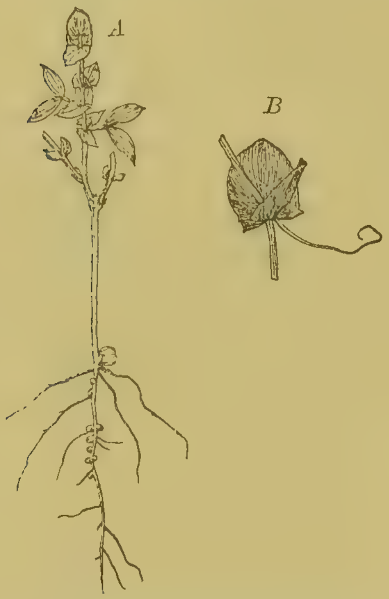

Fig. 285.—*Lathyrus Aphaca*. *A*, seedling; *B*, tendril and stipules from upper part of plant. Both half nat. size.

Nos. 1 and 2. Subulate, acute, very small, and appearing trifid owing to the adnate and similar stipules.

Nos. 3 and 4. Compound, pinnate, with one pair of leaflets and a subulate point; leaflets oblong-elliptic, acute, trinerved longitudinally with smaller intermediate nerves, concave owing to the upcurved sides, entire, glaucous.

Immediately above this the leaves are reduced to small subulate points concealed by the foliaceous stipules.

When the stem has attained some length the leaves on the upper part are developed into tendrils (fig. 285, *B*) as described above, and enable the plant to climb.

TRIBE PHASEOLEÆ.

Clitoria Ternatea, *L.*

Fruit a legume, linear, compressed, more or less thickened at the sutures, dehiscing longitudinally by two valves, many-seeded.

Seed transversely oblong, rounded at either end, much compressed laterally, thicker along the ventral aspect, smooth, black, somewhat shining, minutely reticulate ; hilum a little below the middle of the seed on the ventral aspect, forming a depression and partly overlying a thickened part of the testa corresponding to the chalaza ; micropyle contiguous to the hilum on the ventral aspect, inconspicuous ; raphe none.

Seed 7·25 mm. long, 4·75 mm. wide.

Endosperm absent.

Embryo curved, large, and occupying the whole interior of the seed to which it conforms, brownish-yellow ; cotyledons accumbent with their edges to the placenta, oblong, obtuse, entire, minutely and rather unequally auricled at the base, rather unequal-sided owing to the radicle and the thickening of the chalaza on the ventral aspect, closely applied face to face, thicker along the ventral than the dorsal aspect, equal in length to the interior of the seed ; radicle cylindrical, obtuse, curved round the ends and along the ventral aspect, partly beneath the edges of the cotyledons and having its tip slightly embedded in the micropyle.

In specimens examined the bases of the cotyledons were obliquely cut away owing to the curvature of the seed on the opposite side to that followed by the radicle, so that the auricles on that side were smaller than the others.

Seedling (fig. 286).

Hypocotyl 3 or 4 cm. long, 1·5–2 mm. thick, terete, slightly pubescent, greyish-green, herbaceous.

Cotyledons nearly equal, shortly petioled, about 2 cm. long, 1·25–1·5 cm. broad, 1 mm. thick, oblong, oblique at both ends, entire (one half of blade forming a sector or semicircle with the midrib as base, the other a very long, obtuse rectangle), obscurely penninerved, glabrous, fleshy, yellowish-green on the upper, whitish on the lower surface.

Stem herbaceous, nearly terete, pubescent, light green ; internodes 1 or 2 cm. long, 1–1·5 mm. thick.

Leaves.—Nos. 1 and 2. Opposite, 1·5 cm. above the cotyledons and decussating with them, subsessile or shortly petiolate, stipulate, 2–3 cm. long, about 1 cm. broad, lanceolate, cuneate at base, obtuse at the apex, entire, penninerved with sunk nerves, thin, pubescent, dark green above, dull green below; stipules setaceous.

No. 3. Inserted either at same level with Nos. 1 and 2 or ·5 cm. above those, stipulate, long-petioled; blade sub-bilobed or more generally simple, 2–3 cm. long, about 2 cm. broad, palmatinerved, in nearly all cases showing more or less complete coalition of parenchyma between terminal and lateral leaflets, otherwise like Nos. 1 and 2; petiole 1 or 2 cm. long, 1 mm. thick, with a 2–3 mm. long, thickened, semitransparent articulation at either end, and two setaceous stipules at the base, somewhat channelled, pubescent.

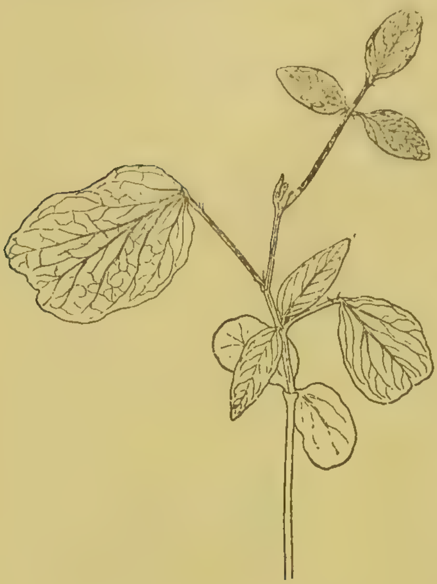
FIG. 286.—*Clitoria Ternatea.*
Half nat. size.

No. 4. As No. 3, only two or three times larger; or as No. 5 &c., which are trifoliolate.

Sometimes only one of the lateral leaflets is free and the other united to the terminal one.

Erythrina suberosa, *Roxb.* (fig. 287).

Hypocotyl undeveloped, or subterranean, and very short.

Cotyledons fleshy and remaining in the oblong testa under the soil until they become exhausted.

Stem erect, stout, tapering upwards, pubescent with spreading or variously directed hairs, pale green, more or less warted or tuberculated from an early stage, with the brownish tubercules very small, soon becoming woody; 1st internode 3·4–4·2 cm. long; 2nd ·8–1 cm.

Leaves simple in the seedling state, cauline, alternate (1st and 2nd opposite), stipulate, petiolate, palmately five- to seven-nerved, or only the three primary and stronger nerves straight, while the others arise from their base, are more slender, and curve round in conformity with the broad, rounded auricles, much reticulate, pubescent on both surfaces, light green above, with somewhat prominent nerves, paler beneath with much more prominent nerves; petioles terete, slightly thickened at the apex under the leaf without any pulvinus, much thickened at its union with the stem; stipules slender, linear-subulate, acute, pale green, hairy, soon becoming brown and falling away early.

Nos. 1 and 2. Opposite, trilobed, with deltoid, acute, or subacute lobes, cordate at the base; middle lobe much the largest.

Nos. 3 and 4. Alternate, simple, much larger, trilobate, cordate at the base, strongly five-nerved; middle lobe somewhat constricted at the base making it rotund, cuspidately acuminate, sometimes showing an obtuse, small, or obsolete tooth on each side; lateral lobes triangular, cuspidately acuminate, with sometimes a small lateral tooth.

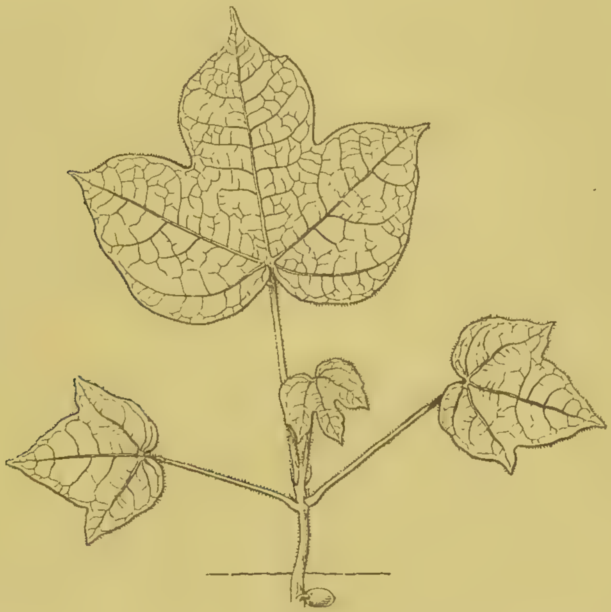

FIG. 287.—*Erythrina suberosa.* One-fourth nat. size.

Erythrina Vespertilio, *Benth.*

Hypocotyl and *cotyledons* as in E. suberosa.

Stem soft and succulent, rather thin, erect, terete, glabrous, pale green; 1st internode 10 cm. long; 2nd 1·8 cm.; 3rd 5 mm.; 4th 4 mm.

Leaves compound, alternate (first four simple, two opposite), glabrous, or pubescent in a very young state, pale green.

Nos. 1–4. Broadly deltoid, cuspidate, obtuse, entire, penninerved, glabrous; stipules ovate, acute, subserrulate; petioles terete, pale green, striped with darker green, glabrous, 1·5–1·8 cm. long;

secondary stipules minute, glandular; pulvinus cylindrical, 3 mm. long.

No. 5. Compound, alternate, pinnately trifoliolate; lateral leaflets rhomboid, acute, petiolulate; terminal leaflet larger and more acuminate; petiolules about 1·5 mm. long; rachis between the leaflets 7 mm. long.

Erythrina monosperma, *Lam.*

Hypocotyl erect, terete, stout, woody, pale green, 7·8 cm. long, and 1 cm. thick.

Cotyledons oblong, obtuse, thick, fleshy, flat or slightly concave above, convex beneath, pale yellow, 2 cm. long, 1 cm. broad.

Stem woody, erect, thick, tapering upwards, pubescent when young, pale green; 1st internode 6·5 cm. long; 2nd 2·5 cm. with a few small spines, as have also those above it; 3rd 1·35 cm. long; 4th 8 mm.

Leaves cauline, compound, alternate (first two simple and opposite); petiole terete, much thickened at the point of insertion, pubescent with brownish, stellately branching hairs; stipules slender, subulate, acute, pubescent.

Nos. 1 and 2. Simple, opposite, entire, rotund-cordate, obtuse or emarginate with a minute tooth in the notch, penninerved and reticulate, glabrous above, pubescent on the nerves beneath (at least when young), deep green above, paler beneath.

No. 3 and succeeding. Pinnately trifoliolate; lateral leaflets triangularly ovate, obtuse, frequently subcordate at the base, penninerved and reticulate, glabrous above, stellately pubescent on the nerves beneath, petiolulate; petiolule stout, cylindrical, covered with a stellately branched pubescence, 5 mm. long; terminal leaflet reniform obtuse, often subcuspidate, entire, truncate at the base, otherwise like the lateral ones; rachis between the leaflets 1·9 cm. long; petiole as in Nos. 1 and 2.

Pueraria Thunbergiana, *Benth.* (fig. 288).

Hypocotyl ascending or suberect, terete, pubescent, pale green, 1·2 cm. long.

Cotyledons thick and rather succulent, oblong, obtuse, shortly petiolate, glabrous, pale green, 1·5 cm. long including petiole, 8 mm. broad.

Stem succulent and tender, terete, zigzag or flexuous, hirsute, pale green; 1st internode 2 mm. long; 2nd 4 mm.; 3rd 4 mm.

Leaves cauline, compound, alternate (first pair simple and opposite), stipulate, petiolate.

Nos. 1 and 2. Subrhomboid-rotund, obtuse, apiculate, penninerved, pubescent on both surfaces; petiole subterete, channelled above, hirsute, articulate at the base and apex, 1·8 cm. long; stipules slender, subulate, acute, hirsute.

No. 3. Pinnately trifoliolate; lateral leaflets obliquely subelliptic, acute, irregularly penninerved, pubescent on both surfaces, entire; terminal leaflet rotund-elliptic acute, subtrinerved at the base, and penninerved upwards, pubescent on both surfaces, entire, petiolulate as are the lateral leaflets; petiolules about 1 mm. long; rachis between the leaflets 8·5 mm. long; petiole subterete, channelled above, hirsute, much thickened at the base, 3·7 cm. long.

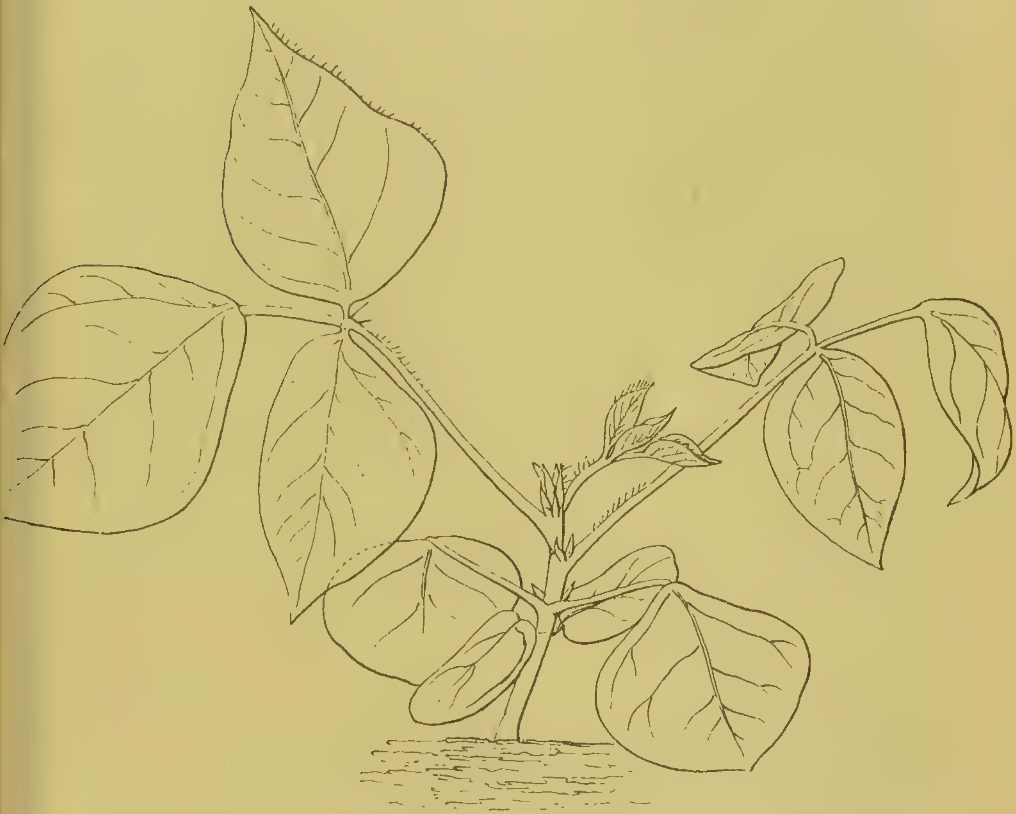

FIG. 288.—*Pueraria Thunbergiana.* Nat. size.

No. 4. Similar to No. 3 but larger; leaflets stipellate, stipellæ filiform, slender, hirsute, deciduous; lateral leaflets very oblique with a strong nerve running into the oblique side.

Ultimate leaves large, pinnately ternate; terminal leaflet elliptic, cuspidate, acute, rounded at the base; lateral leaflets very oblique on the posterior side where a large nerve enters from the base of the leaflet.

Phaseolus multiflorus, *Willd.* (fig. 289).

Fruit a legume, linear, laterally compressed, many-seeded, dehiscing along both sutures.

Seed transversely oblong, with unequal ends (the larger containing the apical ends of the cotyledons), much compressed laterally but convex on both surfaces, smooth, shining, with black markings on a pink ground especially conspicuous towards the hilum, with two minute arilloid processes near the hilum on the ventral edge; hilum oblong-linear, pale-coloured, near the middle of the ventral edge; micropyle rather conspicuous, near one end of the hilum.

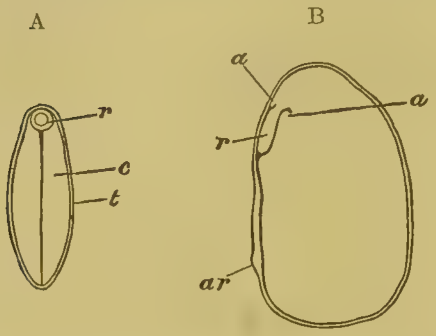

FIG. 289.—*Phaseolus multiflorus.* A, longitudinal section of seed through the cotyledons: *r*, radicle; *c*, cotyledon; *t*, testa. B, longitudinal section of seed in plane of cotyledons, without removing a cotyledon: *a a*, auricles of cotyledons; *r*, radicle; *ar*, minute arilloid. Three-quarters nat. size.

Endosperm absent.

Embryo very large, curved, conforming in outline to that of the seed, pale creamy white; cotyledons large, fleshy, obovate and plano-convex, or subconcave on the inner contiguous faces when dry, forming a hollow between them; radicle stout, tapering to an obtuse point, and curved round towards the micropyle, protruded from and accumbent to the cotyledons; plumule large and well developed, lying between the cotyledons.

Phaseolus vulgaris, *L.*, var. (fig. 290).

Primary root tapering, flexuose, abundantly furnished with lateral rootlets, rather fleshy, colourless, annual.

Hypocotyl stout, fleshy, terete, pubescent, rooting at the base and suddenly narrowed into the root, 7 cm. long, 4·5 mm. thick.

Cotyledons carried above ground by the hypocotyl, fleshy, oblong, obtuse, falcate, turned to one side of the stem, longitudinally wrinkled, pale green, thick, never foliaceous.

Stem herbaceous, erect, subterete or slightly ridged by lines decurrent from the base of the petioles, pubescent; 1st internode 2·4 cm. long.

Leaves compound, pinnately trifoliolate (first pair opposite and unifoliolate), cauline, alternate, stipulate, petiolate, pubescent, petioles subterete, pubescent, channelled on the upper side, pale green; stipules lanceolate, acute, entire (those of the primary and opposite leaves interpetiolar and connate into a subulate acute, entire or bifid piece).

Nos. 1 and 2. Opposite, unifoliolate; leaflets subtriangular, obtuse, strongly five-nerved and reticulate, with a large wide open sinus at the base; nerves ascending and incurved, the basal ones branching into the auricles.

No. 2. Alternate, pinnately trifoliolate; leaflets stipellate.

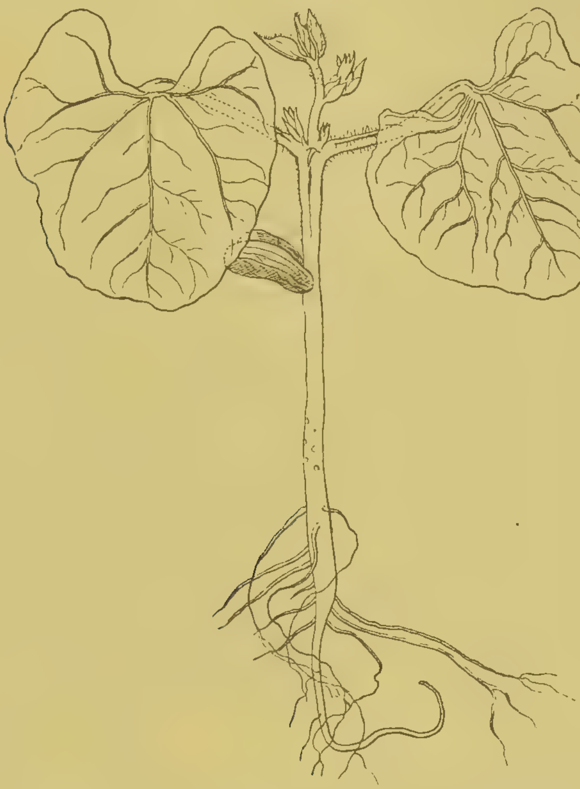

FIG. 290.—*Phaseolus vulgaris*, var. Half nat. size.

Vigna lutea, *A. Gray.*

Hypocotyl none.

Cotyledons subterranean.

Stem erect, terete below, then angled from the leaf-base downward with three decurrent nerves, pale green, frequently suffused with purple; 1st internode 5·5 cm. long; 2nd 4 mm.

Leaves cauline, compound, alternate (Nos. 1 and 2 simple and opposite), stipulate, petiolate, glabrous or with a few scattered adpressed hairs underneath when young, pale green and shining.

Nos. 1 and 2. Ovate, acute, entire, subcordate and trinerved at the base, reticulate; petiole flattened and pubescent above, 4 mm. long; stipules of first pair interpetiolar and connate, ovate, acute, entire or emarginate.

No. 3. Pinnately trifoliolate; leaflets ovate, acute, or apiculate, petiolulate, stipellate; petiolules 2 mm. long; stipellæ small, ovate, acute; stipules triangularly ovate, acute, subauricled at the base; petiole angled, channelled above, 2 cm. long.

Ultimate leaves pinnately trifoliolate, leaflets oblong-ovate or oval, obtuse, apiculate, entire, terminal one generally somewhat the largest.

Vigna vexillata, *Benth.*

Hypocotyl and *cotyledons* as in V. lutea.

Stem herbaceous, terete and striate or shallowly furrowed, pubescent, erect at first, climbing above the third internode; 1st internode 6 cm. long; 2nd 1·9 cm.; 3rd 2·7 cm.; 4th and others climbing or rather twining from right to left.

Leaves cauline, compound, alternate (first two simple, opposite); petiole subterete, channelled above, pubescent; stipules short, ovate, acute, subauricled at the base, pubescent.

Nos. 1 and 2. Lanceolate, acute, entire, penninerved, pubescent on both surfaces, caducous; petiole about 2 mm. long; stipules interpetiolar, subulate, connate into one.

No. 3 and succeeding leaves. Pinnately trifoliolate; leaflets about equal, lanceolate, acute, penninerved, pubescent on both surfaces; petiole subterete, channelled above, pubescent; rachis between leaflets 3·5 mm. long; secondary stipules minute, subulate, acute.

Pachyrhizus angulatus, *Rich.*

Primary root tuberous; lower part tapering and giving off lateral rootlets.

Hypocotyl undeveloped, or subterranean.

Cotyledons reniform, subterranean, conforming to the shape of the seed.

Stem annual, twining against the sun, terete, striate, covered with an adpressed pubescence, green; 1st internode about 3·5 cm. long; 2nd when developed, 1–9 mm.; 3rd 1·5–3·5 mm., commencing to twine and lengthening.

Leaves cauline, compound, alternate (first and second frequently opposite, always simple), stipulate, petiolate.

Nos. 1 and 2. Simple, opposite or alternate; petiole subterete, channelled on the upper side, pubescent; stipules and stipellæ subulate, slender; lamina triangular, cuspidate, truncate at the base, five-nerved, sparsely pubescent on both sides; nerves incurved.

No. 3. Pinnately trifoliolate, silky when young; lateral leaflets ovate, acuminate, entire; terminal leaflet triangularly ovate, entire or with one or two teeth.

Ultimate leaves pinnately trifoliolate; lateral leaflets very obliquely triangular acuminate, entire, angled, or toothed on the posterior, oblique side; terminal one very broadly deltoid, suddenly acuminate, entire, or angled at the sides, or trifid and toothed.

Atylosia Candollei, *W. et Arn.* (fig. 291).

Primary root vertical, firm, long, with a few lateral fibres.

Hypocotyl undeveloped.

Cotyledons subterranean, minute, 4 mm. long, 2 mm. broad, sessile, oblong, obtuse.

Stem terete, pubescent, grey near the base, green higher up.

Leaves digitately or pinnately trifoliolate, cauline, alternate (first two opposite), stipulate, petiolate, alternately incurvinerved, reticulate, pubescent or hairy all over, but especially when young, bright green above, paler beneath, membranous, dotted beneath with resin glands; stipules thin, subulate, acute.

Nos. 1 and 2. Opposite, equal, simple, entire, subsessile, 2–3 cm. long, about 1·5 cm. broad, ovate or ovate-lanceolate, subcordate at base, more or less obtuse at apex, pubescent all over, thin, bright green.

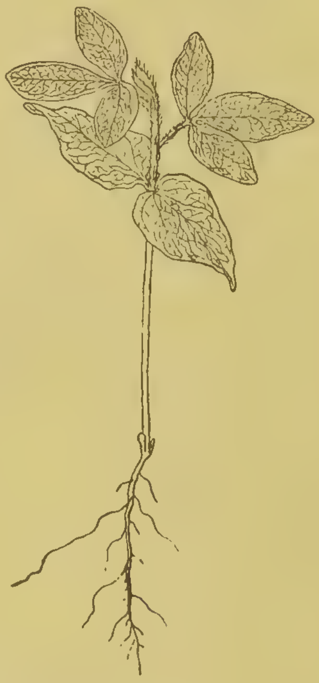

FIG. 291.
Atylosia Candollei.
Three-fifths nat. size.

Nos. 3–5. Ternate, alternate, more hairy; leaflets elliptic, obtuse, sessile.

Flemingia Grahamiana, *W. et Arn.*

Hypocotyl none or subterranean.

Cotyledons subterranean.

Stem wiry, erect, terete, pubescent, and closely dotted with red sessile glands, as are the leaves on both sides and the petioles; 1st internode 3 cm. long; 2nd 6 mm.; 3rd 1 mm.; 4th 4 mm.; 5th 4·5 mm.

Leaves cauline, compound, alternate (first two simple and opposite), stipulate, petiolate.

Nos. 1 and 2. Simple, opposite, rotund-ovate, obtuse or apiculate, ciliate, covered on both sides with small sessile red glands, opaque, subtrinerved; petiole 2 mm. long; stipules free, interpetiolar, linear-subulate, acute, slender.

No. 3. Digitately trifoliolate; lateral leaflets oblique, oval, obtuse, mucronate, penninerved with a strong nerve on the oblique side; terminal leaflet elliptic, obtuse, mucronate, trinerved, nerves ascending or slightly incurved; petiole deeply channelled above, dilated into a fleshy foot at the base, variable in length, averaging about 1·8 cm. long; petiolules about 1 mm. long; stipules opposite the leaf and more or less connate for two-thirds or three-fourths of their length, adpressed to the stem with ovate acute free teeth.

Nos. 4–6. Similar, but larger.

Ultimate leaves digitately or subpinnately trifoliolate; lateral leaflets obliquely ovate, apiculate; terminal one elliptic, obtuse at both ends, apiculate, trinerved.

Galactia glabella, *Michx.*

Cotyledons just emerging from the soil, shortly oblong, fleshy, convex on the back, flat on the face.

Leaves.—Nos. 1 and 2. Simple, cordate, cuspidate, entire, deep green, opposite.

No. 3. Alternate, pinnately trifoliolate; terminal leaflet oblong, obtuse, emarginate; lateral leaflets oblong or ovate, obtuse, emarginate.

TRIBE DALBERGIEÆ.

Dalbergia hupeana, *Auct.*

Hypocotyl 3 cm. long, erect, terete, glabrous, light green.

Cotyledons thick, fleshy, obtusely and obliquely ovate, wrinkled, dark green, glabrous, very shortly petiolate or subsessile, 8 mm. long, 5 mm. wide, distinctly one-nerved.

Stem herbaceous, ultimately becoming woody, erect, terete, slightly hoary; 1st internode from 2·5–3·5 cm.; 2nd considerably shorter, about 1 mm.

Leaves compound, pinnate, with seven or more leaflets, alternate, but so near together that they appear opposite, stipulate, though this genus is usually exstipulate.

Leaflets entire, alternate, obovate, with short petiolules, almost sessile, bright green, rather reflexed, slightly cuspidate; midrib with numerous ascending branched veinlets.

Pterocarpus Rohrii, *Vahl.*

Primary root stout, long, tapering, unbranched in the younger stages.

Hypocotyl erect, terete, glabrous, 5–7 cm. long.

Cotyledons ovate-oblong, obtuse, unequal at the base, the longer side being rounded, and the other hastate, fleshy, glabrous, three- to five-nerved, but the venation obscure owing to their opaque character, ascending, flat at first, but soon becoming revolute at the sides and falling early, subsessile with a petiole or narrowed portion only 1 mm. long.

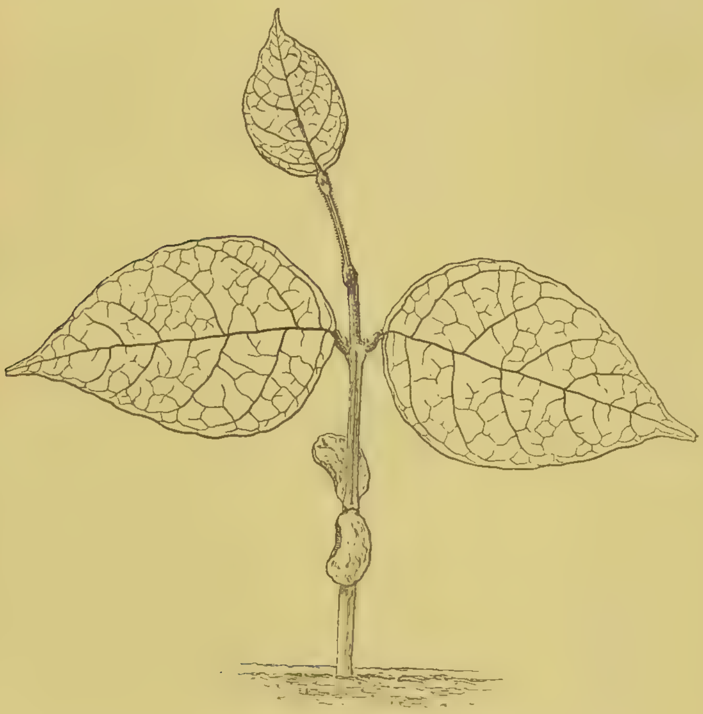

Fig. 292.—*Lonchocarpus latifolius.* Half nat. size.

Stem erect, bluntly subquadrangular in the young state, soon becoming woody, glabrous ; 1st internode 4–5 cm. long.

Leaves alternate, imparipinnate except the first pair, stipulate, petiolate, glabrous ; leaflets alternate or irregularly opposite, exstipellate, thinly coriaceous, shining above ; petioles slender, semiterete, narrowly channelled above, slightly thickened at the base and pulvinate ; stipules subulate, acuminate, slender, acute.

1st pair opposite, each leaf consisting of one cordate, strongly acuminate leaflet, with a slender point, and alternate, long, incurved lateral nerves not reaching the margin ; there is a pulvinus at the base of the petiole, and another at the base of the lamina or leaflet; stipules interpetiolar and connate.

I have seen but few examples of the Dalbergieæ, and the semi-hastate cotyledons of this species are unique in the Order as far as observed. The first pair of leaves being opposite and consisting of only one leaflet point to an affinity with the Phaseoleæ, the tribe coming immediately before the Dalbergieæ in the arrangement of the 'Genera Plantarum.'

Lonchocarpus latifolius, *H. B. et K.* (fig. 292).

Hypocotyl erect, terete, glabrous, deep green, 3·4–3·8 cm. long.

Cotyledons falcate, obtuse, subsessile, both directed to one side of the stem, aerial but fleshy, plano-convex, enlarging but slightly after germination, and deciduous at an early date, before which they become bright yellow, 1·5–1·8 cm. long, 7–8·25 mm. wide.

Stem erect, terete, deep green, densely and finely pubescent, ultimately woody and arborescent; 1st internode 3·25 cm. long; 2nd undeveloped; 3rd 1·15 cm.

Leaves simple and compound, imparipinnate, cauline, alternate, stipulate, petiolate, pubescent at the margin and on the nerves above, alternately incurvinerved and reticulate, dull deep green above, paler beneath; stipules small, subulate, erect, or tooth-like and shorter, pubescent; petioles subterete, shallowly channelled above, densely pubescent, of the first two leaves short, of the rest much longer.

Nos. 1 and 2. Opposite, ovate, cuspidately acuminate, obtuse, simple and entire, or minutely emarginate.

No. 3. Alternate, ovate, acuminate, acute or subacute, simple and entire.

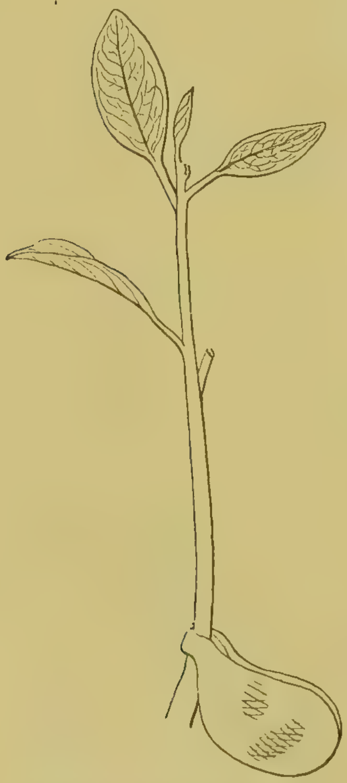

FIG. 293.—*Sophora secundiflora*. Nat. size.

TRIBE SOPHOREÆ.

Sophora secundiflora, *Lag.* (fig. 293).

Seeds scarlet, with a shell as hard as ivory.

Hypocotyl undeveloped.

Cotyledons remaining below the ground with their faces closely adpressed, 1–1·5 cm. long, nearly 1 cm. broad, 3–5 mm. thick, fleshy.

Stem slightly curved, terete, firm, glabrous, greyish-green; 1st internode 3–4 cm. long, 2–3 mm. thick; 3rd about the same; 2nd and 4th very short.

Leaves imparipinnate (or one or more of the primary ones simple), cauline, alternate, stipulate, petiolate, alternately incurvinerved and reticulate, glabrous, deep green above; stipules minute, apparently caducous.

No. 1. Shortly stalked, 2·5–3 cm. long, 5–6 mm. broad, linear or linear-lanceolate, more or less acute, thinly coriaceous, glabrous, dark green.

No. 2. Ditto.

Nos. 3 and 4. Ditto, but elliptic-lanceolate, acuminate at both ends with articulation between blade and petiole.

Edwardsia chilensis, *Miers* (fig. 294).

Hypocotyl subterranean.

Cotyledons not rising above ground, thick, fleshy, flat on one side and very convex on the other, conforming to the shape of the seed, greenish, 1·5 cm. long, 1 cm. broad.

Stem erect, terete, woody, verrucose, pubescent, deep green; 1st internode 6 mm. long; 2nd 3 mm.; 3rd 4 mm.; 4th 7 mm.; 5th 7 mm.; 6th 9·5 mm.; 7th 1·2 cm.

Leaves compound, imparipinnate, cauline, alternate, stipulate, petiolate, glabrous above and dark green, sparsely pubescent on the under side, petiole and rachis paler green; petiole-semiterete, channelled on the upper side; stipules small, tooth-like, inconspicuous.

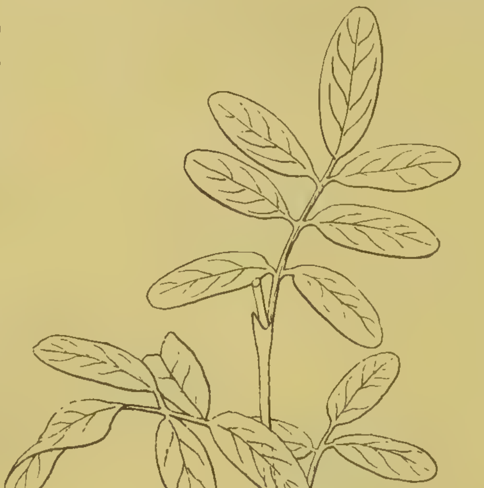

Fig. 294.—*Edwardsia chilensis.* Nat. size.

No. 1. Unifoliolate, small; leaflet obovate.

No. 2. Trifoliolate; leaflets unequal.

No. 3. Quadrifoliolate; an extra, small, lateral leaflet present at the base of the terminal one, but probably a malformation.

No. 4. Trifoliolate; leaflets oblong, obtuse, minutely emarginate; terminal leaflet largest. This applies to most or all of the leaflets that follow.

Nos. 5 and 6. Five-foliolate.

Nos. 7–10. Seven-foliolate.

Castanospermum australe, *A. Cunn.* (fig. 295).

Primary root long, tapering, stout, giving off lateral, branched fibres.

Hypocotyl undeveloped.

Cotyledons enormously large, semiglobose, fleshy, filling the seed and conforming to it in shape, persistent and subterranean, remaining in the testa which splits irregularly.

Plumule very large and well developed, fleshy.

Stem erect, terete, ultimately woody, and forming a tall tree.

Leaves compound, imparipinnate, cauline, alternate, stipulate, petiolate; leaflets large, leathery, exstipellate.

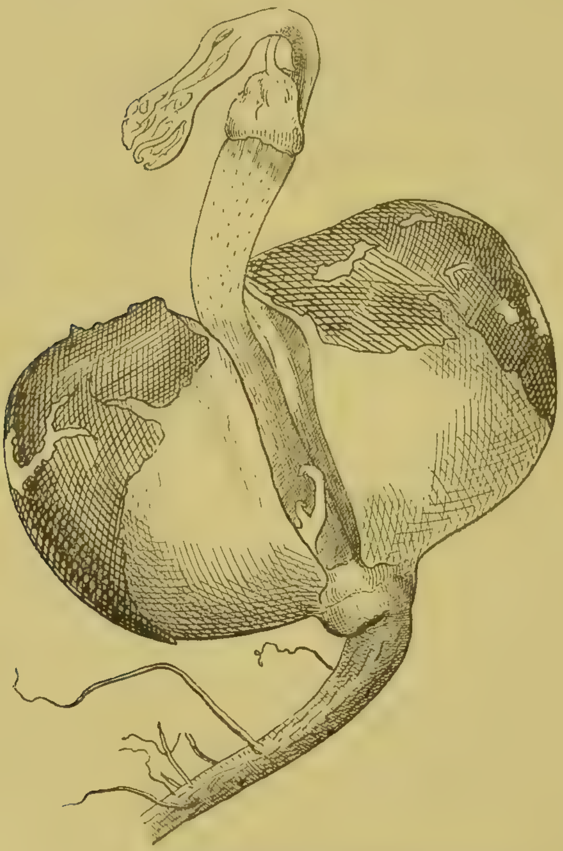
Fig. 295.—*Castanospermum australe.* Nat. size.

Myroxylon peruiferum, *L. fil.*

Hypocotyl usually subterranean.

Cotyledons fleshy and remaining in the large seed till they are exhausted and decay.

Stem woody, erect, terete, pubescent, pale green, ultimately grey, slightly warted; 1st internode 7·65 cm. long; 2nd 1·4 cm.; 3rd 1·05 cm; 4th 1·1 cm.; 5th 1·25 cm.; 6th 8 mm.

Leaves compound, pinnate with alternate leaflets (those of the first four to five leaves mostly opposite), cauline, alternate (first two opposite), stipulate, petiolate, permeated with small, linear-oblong, dot-like glands, ciliated on the margin, pubescent on the petiole and on the rachis and midrib of leaflets on both surfaces, deep green above, paler beneath, shining on both surfaces, evergreen, coriaceous, thin; leaflets slightly undulate, and subrevolute at the extreme margin, shallowly wavy or subcrenulate in the adult leaves; petioles terete, thickened at the base and articulated with the stem; stipules small, linear, obtuse, pubescent, tending to become obsolete as they proceed from the first pair of leaves upward.

Nos. 1 and 2. Opposite; leaflets five, lanceolate, obtuse, emarginate, as are those of the third to seventh leaf.

No. 3. With eight leaflets.

No. 4. With nine leaflets.

No. 5. Deformed.

No. 6. With nine leaflets.

No. 7. With eleven leaflets.

Ultimate leaves pinnate, with nine to thirteen alternate leaflets and a terminal elliptic, obtuse, emarginate one; lateral leaflets oblong, obtuse, emarginate, or a few of the lower ones ovate.

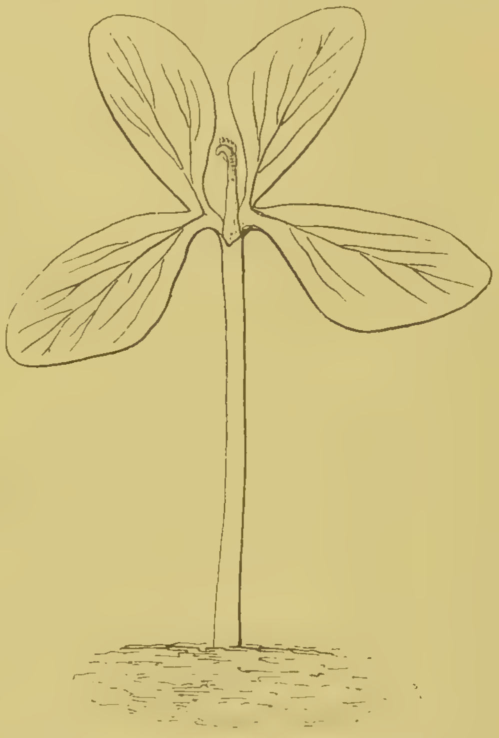

FIG. 296.
Hæmatoxylon campechianum, × 2.

Hæmatoxylon campechianum, *L.*

Fruit a legume, much flattened dorsally, one-seeded.

Seed oblong-oval, 8–12 mm. long, exalbuminous, very much laterally flattened; testa straw-coloured, smooth, thickened near the hilum; hilum rather conspicuous, ventral.

Embryo straight, filling the whole interior of the seed, yellowish; cotyledons deeply bilobed, transversely oblong, consisting chiefly of two large auricles, obtuse, veined while still in the seed, lying the broad way of the seed, with their edges to the axis; radicle short, subquadrangular, subacute, lying between the two lobes of the cotyledon, but not incumbent on them.

Seedling (fig. 296).

Hypocotyl erect, terete, glabrous, 2–2·5 cm. long, light green or colourless.

Cotyledons membranous, unequal, unsymmetrical, deeply bipartite, shortly petiolate; segments obliquely oblong, ovate, obtuse, entire, glabrous, dark green, distinctly pinnatinerved; the lateral veins very long.

Stem erect, terete, glabrous, herbaceous, ultimately woody.

TRIBE EUCÆSALPINIEÆ.

Cæsalpinia tinctoria, *Domb.* (fig. 297).

Hypocotyl long, woody, striated, 5–6 cm. long, brownish.

Cotyledons obovately rotund, subfleshy, obtuse, entire, slightly auricled at the base, subsessile or very shortly petiolate, glabrous, dark green, trinerved, with the principal nerves again pinnatinerved.

Stem erect, square, herbaceous (ultimately woody) minutely pubescent; 1st internode 5–6 mm. long; 2nd internode 7–9 mm.

First two leaves compound, abruptly pinnate, cauline, alternate, petiolate, stipulate, ending in a short point; third leaf bipinnate; leaflets simple, opposite, oval-oblong, acute, ending in a sharp point or mucro, shortly petiolulate, stipellate, glabrous, green, pinnatinerved; petioles long, terete, pubescent; stipules and stipellæ straight, acute, thorn- or bristle-like.

Tubeuf[1] figures and describes the seedling of Gleditschia triacanthos, which somewhat resembles the above, but the cotyledons are oval, 2·5 cm. long, and 1·2 cm. broad, and sessile. The first leaves have ten pairs of pinnæ, which are shortly stalked, have a delicate pointed apex, and are hairy.

Poinciana Gilliesii, *Hook.* (fig. 298).

Hypocotyl erect, square, with slightly winged ribs, and a few short brown hairs on the upper part, 4–5 cm. long; light subglaucous-green.

Cotyledons broadly or obovately oblong, obtuse, entire, very shortly petiolate, glabrous, light subglaucous-green, five-nerved at the base, with the main nerve forking near the apex; petioles connate at the base.

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[1] *Samen, Früchte u. Keimlinge* (Berlin, 1891), p. 127.

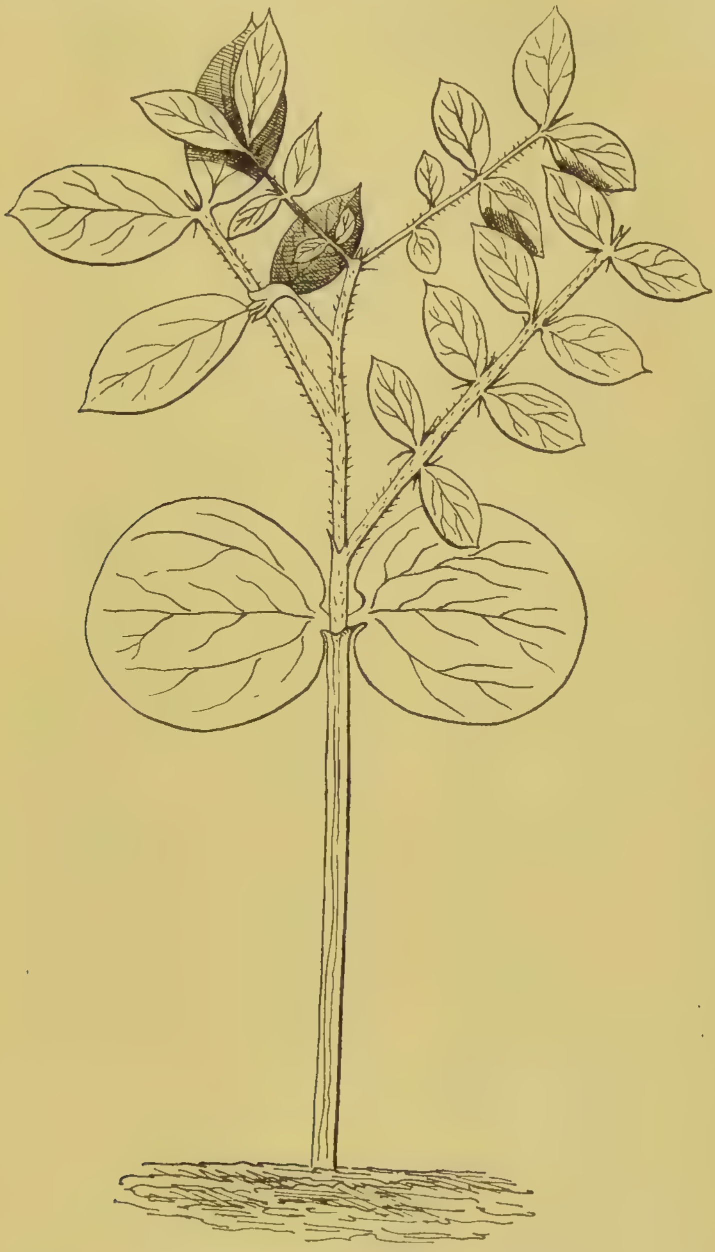

FIG. 297.—*Cæsalpinia tinctoria.* Nat. size.

Stem erect, terete, herbaceous, covered with short brown hairs; 1st internode 2·5–3 mm. long.

First leaves compound, abruptly pinnate, cauline, alternate with long petioles, stipulate; leaflets linear-oblong, obtuse, entire, shortly petiolulate, opposite (sometimes alternate), glabrous, light green, pinnatinerved; petioles terete, with a few scattered hairs; stipules obovate, jagged or denticulate, minutely hairy.

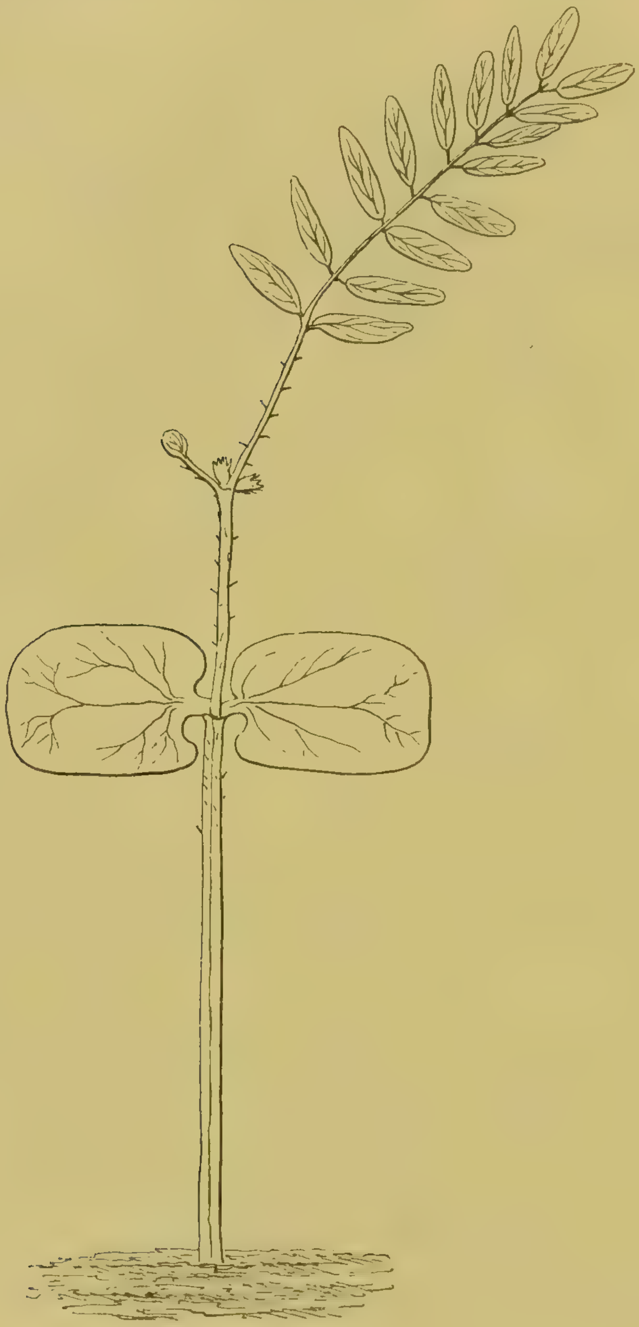

Fig. 298.—*Poinciana Gilliesii.* Nat. size.

TRIBE CASSIEÆ.

Cassia circinata, *Benth.* (fig. 299).

Hypocotyl erect, terete, wiry, suffrutescent, pubescent, 2·5–4·5 cm. long, pale green at first, ultimately brown.

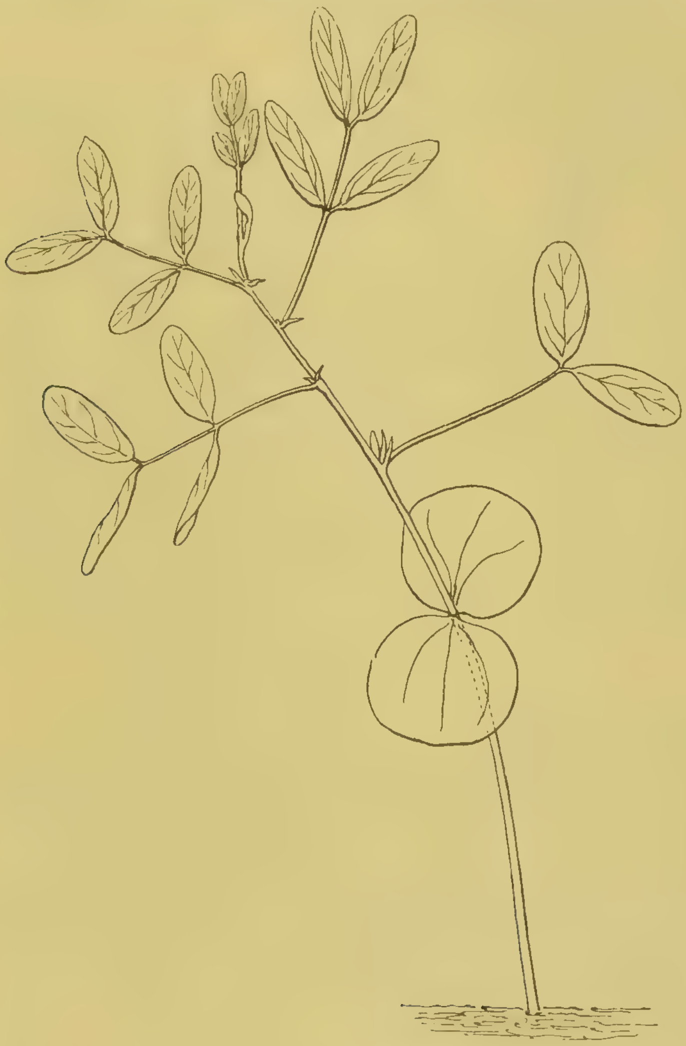

FIG. 299.—*Cassia circinata.* Nat. size.

Cotyledons foliaceous, shortly petiolate, rotund, deep green above, indistinctly three- to five-nerved, paler beneath; petiole about 1 mm. long.

Stem wiry, suffrutescent, terete, pubescent, pale green; 1st internode 1·8 cm. long; 2nd 9 mm.; 3rd 6·5 mm.; 4th 7 mm.

Leaves cauline, compound, alternate, stipulate, petiolate.

No. 1. Pinnate, abrupt, with one or sometimes two pairs of leaflets; leaflets oblong, or obovate-oblong, obtuse, pale green above, glaucous beneath, ciliate, petiolulate; petiole subterete, channelled above, pubescent, 1·5 cm. long; petiolule 1 mm. long; stipules linear, acute, pubescent.

Nos. 2–5 of two pairs of leaflets; leaflets opposite; rachis abrupt; otherwise similar to No. 1.

Cassia obovata, *Coll.* (fig. 300).

Hypocotyl stout, glabrous, light green, 1·5–2 cm. long, stout.

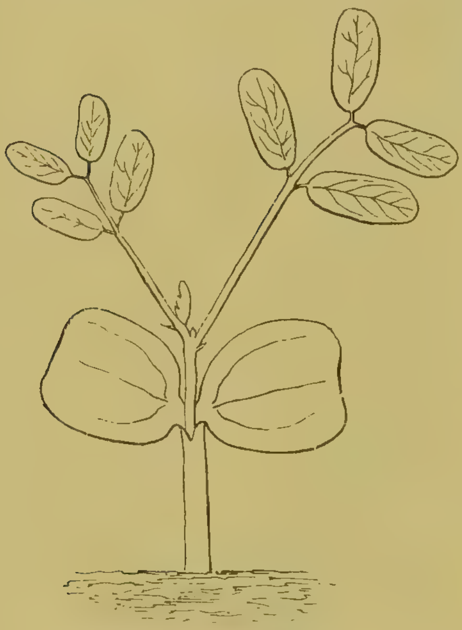

FIG. 300.—*Cassia obovata.* Nat. size.

Cotyledons broadly obovate, obtuse, entire or widely emarginate, nearly sessile, glabrous, light subglaucous-green, distinctly trinerved.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 4–5 mm. long; 2nd shorter.

First leaves abruptly pinnate, petioles long; leaflets oblong, obtuse, entire, opposite, shortly petiolulate, glabrous, green, alternately pinnatinerved; stipules small, setaceous, deciduous.

Cassia mimosoides, *L.*

Hypocotyl slender, 1·5 cm. long, ·5–·75 mm. thick, uneven but glabrous and terete.

Cotyledons horizontal, subsessile, about 9 mm. long and 5 mm. broad, obliquely oblong, rounded at the apex, entire, obscurely nerved, with a revolute margin, glabrous but showing dark brown dots on both surfaces, pale green.

Stem pubescent, not very firm, red; first internode 2–3 cm. long and ·5 mm. thick.

Leaves abruptly pinnate; leaflets small, linear-oblong, obtuse, entire with an evident midrib; stipules small, scarious, subulate, acute.

No. 1. Abruptly pinnate, 1–2 cm. long, ·75 cm. broad, with about seven pairs of oblique, linear-oblong, sessile leaflets 3–4 mm. long and 1–2 mm. broad.

No. 2. Similar.

Cassia Fistula, *L.* (fig. 301).

Fruit a legume, linear, slightly compressed laterally, divided into many cells transversely by ingrowths of the carpel, many-seeded, thick, indehiscent.

Seed rotund-obovate, much compressed dorso-ventrally, glabrous, hard, shining; testa thin, pale-coloured, and separating from the tegmen, forming a broad white band down the middle of the ventral aspect, and a broader one along the dorsal aspect, while round the edges it remains attached and appears deep buff or brownish-yellow; tegmen much thicker and brownish-yellow; micropyle and hilum contiguous, basal at the upper end of the seed; raphe ventral, forming a brown line almost obscured by the white testa; chalaza apical, at the farther end from the hilum.

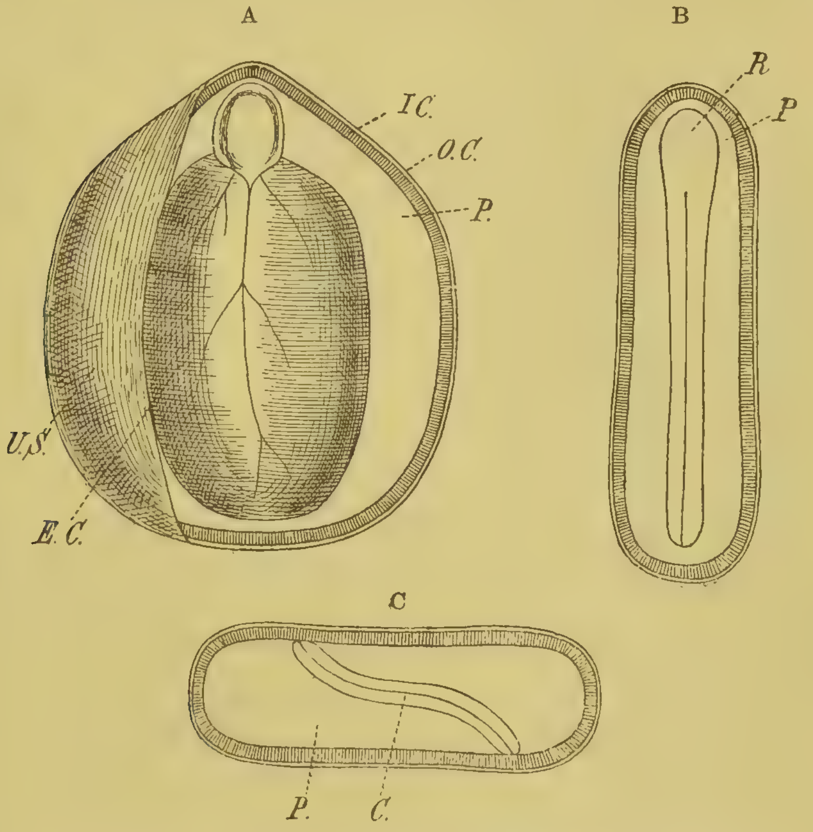

FIG. 301.—*Cassia Fistula.* A, oblique longitudinal section of seed, × 5: *US*, uncut surface; *EC*, edges of cotyledons; *P*, endosperm; *OC*, testa; *IC*, tegmen. B, longitudinal section of seed at right angles to the plane of the cotyledons, × 5: *R*, radicle; *P*, endosperm. C, transverse section of seed, × 5: *P*, endosperm; *C*, cotyledons.

Endosperm copious, very tough and almost colourless when moist, hard and cartilaginous when dry, occupying the greater part of the interior of the seed.

Embryo large and nearly as long as the endosperm, straight, central, but obliquely twisted, so that in transverse section it traverses the endosperm diagonally by two curves, the edges of the cotyledons abutting against the inner wall of the seed and cutting the endosperm in two; cotyledons oblong, obtuse, entire, slightly cordate at the base, trinerved longitudinally, while short, alternate, ascending nerves are given off from the midrib, closely applied face to face, thick, flat, rather fleshy, pale yellow; radicle very short, stout, obtuse, subovoid, lying in a cavity of the endosperm close to the micropyle, straight, many times shorter than the cotyledons.

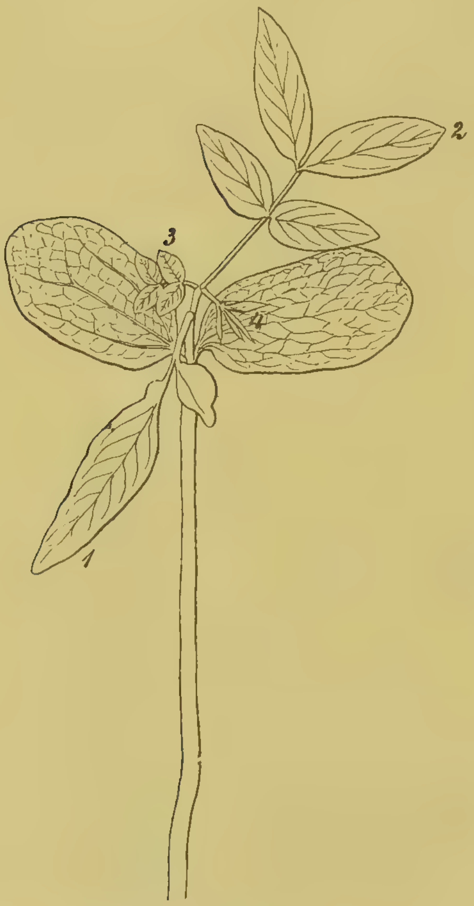

Fig. 302.—*Cassia Fistula.* Nat. size.

Seedling (fig. 302).

Hypocotyl woody, erect, terete, substriate by the bursting of the epidermis, finely pubescent, glabrescent, green and afterwards becoming brown, 4–6 cm. long.

Cotyledons foliaceous, shortly petiolate, oblong or obovate-oblong, rounded at the end, trinerved and reticulate, 2·4 cm. long, 1·4 cm. broad.

Stem woody, erect, flexuous or zigzag at the joints, terete, pubescent, green; 1st internode 5 mm. long; 2nd, 3rd, and 4th each about 1 mm.; 5th 2 mm.; 6th 3·5 mm.; 7th 4 mm.

Leaves cauline, alternate, compound, stipulate, petiolate, abruptly pinnate; petioles and under side of leaflets pubescent; upper side glabrous, deep green; under side pale or glaucous.

No. 1. Consisting of one pair of deformed, unequal-sized leaflets.

No. 2. Of two pairs of oblong-lanceolate, acute or subacute leaflets.

Nos. 3 and 4. Very small, each with two pairs of leaflets.

Nos. 5–7. Of two pairs of leaflets; lower pair ovate, obtuse, penninerved and reticulate, entire, petiolulate; upper pair ovate-oblong or oblong-lanceolate, obtuse, otherwise like the lower pair; petiole subterete, slightly channelled above, 9–15 mm. long; primary rachis 8–9 mm. long, ending in a mucro between the upper pair of leaflets; petiolules about ·1 mm. long.

TRIBE BAUHINIEÆ.

Bauhinia tomentosa, *L.* (fig. 303).

Seeds oblong, subrotund or orbicular, much compressed laterally, 6·5–8 mm. long, 5–7 mm. wide, 2–2·25 mm. thick, not transverse to the placenta.

Hypocotyl erect, terete, subglabrous, pale green, 1·25–1·8 cm. long.

Cotyledons foliaceous, obovate-oblong, obtuse and rounded at both ends, five-nerved from the base in a somewhat radiating manner, glabrous and shining on both surfaces, light green above, paler beneath, subfleshy, sessile, 2·1 cm. long, 1·2 cm. wide.

Stem shrubby after a time, erect, terete, hairy, pale green when young; 1st internode 1·45 cm. long.

Leaves simple, bilobed (apparently consisting of two united leaflets), cauline, alternate, stipulate, petiolate, more or less hairy on both surfaces (in the seedling), five-nerved, reticulate, with the median nerve prolonged or aristate in the apical sinus, with strong branches running to the apex of the lobes, and the lateral ones ascendingly penninerved; petioles semiterete, channelled above, hairy; stipules small, subulate, acute, colourless.

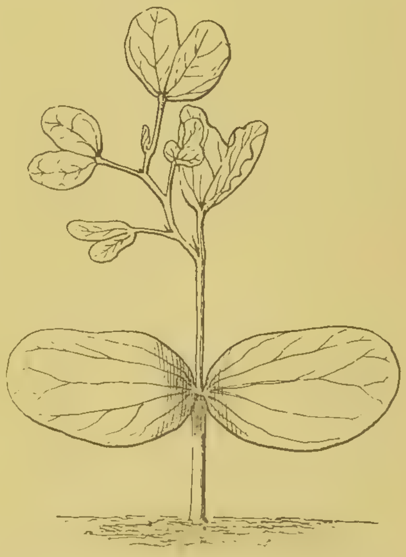

FIG. 303.—*Bauhinia tomentosa.* Nat. size.

No. 1. Broadly obcordate, rounded at the base, divided at the apex for about one-fourth its length, with the lobes rounded and obtuse.

Nos. 2 and 3. (Deformed in specimen).

Nos. 4 and 5. Similar to No. 1, but smaller.

Bauhinia Carronii, *F. Muell.*

Pods 8–10 cm. long, 2·5–3 cm. broad, scarlet when young, the colour of the flowers, which they resemble at a distance.

Seeds oblong or broadly oblong, much compressed laterally, smooth, shining, deep chestnut brown, glabrous, 9–10·5 mm. long, 6–8·5 mm. broad, 2·25–2·75 mm. thick.

Hypocotyl subterranean.

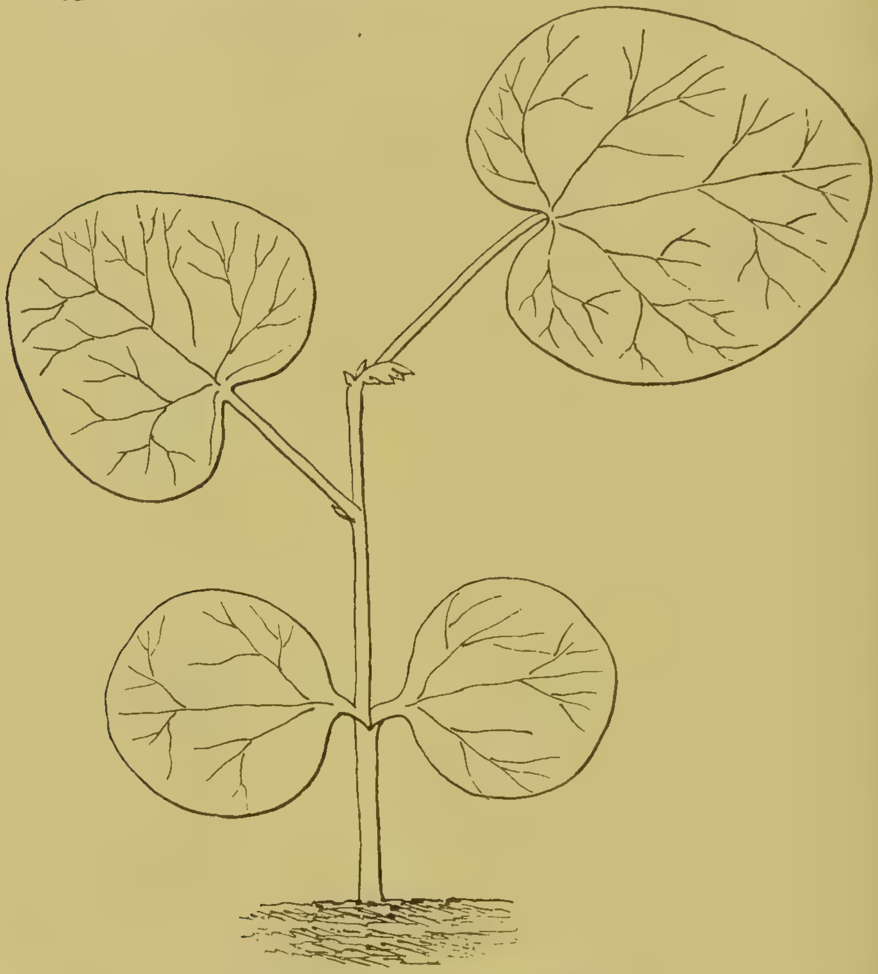

FIG. 304.—*Cercis Siliquastrum*, × 2.

Cotyledons sessile, one below the earth, about 1·5 cm. long, 1 cm. broad, oblong or obovate, obtuse, entire, trinerved, subconcave, glabrous, succulent, light green above.

Stem herbaceous, terete, about 2 mm. thick, very pale green; 1st internode 3·2 cm. long; 2nd 2·1 cm.; 3rd 2 cm.; 4th 1·7 cm.

Leaves.—No. 1. Very small, cauline, compound, of two leaflets;

petiole 1 mm. long; leaflets oblanceolate or oblong, obtuse, 5 mm. long, 2 mm. broad, otherwise like No. 2.

No. 2 &c. Compound, cauline, stipulate, petiolate, of one pair of leaflets, glabrous, palmatinerved, reticulate; leaflets opposite, obovate, slightly oblique, entire, obtuse and rounded at the apex, subcuneate at the base, pale green and subglaucous on both sides, 1·5 cm. long, 7 mm. broad; stipules free, small, subulate, acute; petiole terete, or faintly channelled on the upper side, minutely pubescent, 3 mm. long, produced beyond the bases of the leaflets into a slender, subulate, acute point.

Cercis Siliquastrum,[1] *Willd.* (fig. 304).

Hypocotyl short, erect, terete, 5–6 mm. long, light green or colourless.

Cotyledons rotund, obtuse, entire, shortly petiolate, coriaceous, dark green, glabrous, pinnatinerved or rather trinerved, with numerous branched veinlets to the principal veins.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 1–1·2 cm. long; 2nd 5–7 mm.

First leaves simple, entire, cauline, alternate, petiolate, stipulate, cordate or ovate from a cordate base, obtuse, glabrous, light green, pinnatinerved or five-nerved; petioles rather long, slender, terete; stipules small, acute, setaceous, deciduous.

TRIBE AMHERSTIEÆ.

Peltogyne sp.

Primary root long, tapering, giving off numerous short lateral rootlets.

Hypocotyl erect, obtusely tetragonal owing to the lines running down from the cotyledons, 13·5–14·5 cm. long, glabrous, soon becoming woody.

Cotyledons broadly oval, obtuse, fleshy, green but opaque, with obscure or indiscernible venation, sessile, rather strongly auricled at the base with the auricles connate for most of their length along the dorsal aspect, and deeply grooved in front so that they appear to be attached to the axis about 4·5 mm. above their base, erect for some time after germination, then recurved and spreading a little above their insertion, rather caducous.

Stem soon becoming woody; 1st internode about 4 mm. long.

Leaves compound, consisting of one pair of leaflets, like some species of Bauhinia, cauline, stipulate, petiolate, coriaceous, glabrous, shining; leaflets very unequal-sided or half-ovate, obtuse, sessile, with the midrib near the inner edge or anterior margin, and a few strong incurved nerves (not reaching the margin) on the posterior side; petiole short, semiterete, grooved above in the first pair, and about 1·5 cm. long; stipules slender, short, subulate, soon becoming brown.

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[1] Cf. Tubeuf, *loc. cit.* p. 128, fig. 174.

Nos. 1 and 2. Opposite, with the characters as above given.

Hymenæa Courbaril, *L.* (fig. 305).

Hypocotyl erect, terete, stout, succulent, glabrous, pale brownish-green, 8·5 cm. long, 5 mm. thick at the base.

Cotyledons thick, fleshy, plano-convex, oval in outline, slightly emarginate, pale brownish on the back, light green above (the green part being bordered by a narrow rim), glabrous, red on the back when quite young, semi-erect, auricled at the base behind, and forming a short sheath, 2·2 cm. long including the sheath, 1·4 cm. broad, 7 mm. thick a little above the base.

Stem succulent at first, ultimately woody, green, glabrous; 1st internode 3·3 cm. long; 2nd 4·15 cm.

Leaves.—Nos. 1 and 2. Simple, opposite, exstipulate, cohering nearly throughout the whole length of their petioles and adnate to the stem; lamina obliquely rotund, emarginate, 5–6-nerved longitudinally and finely reticulate, 5 cm. long, 5·5 cm. broad, ascending.

No. 3. Alternate, abruptly pinnate, stipulate, with one pair of leaflets; leaflets obliquely ovate, acuminate, obtuse, conduplicate in bud, and adpressed to each other by the backs of their narrow anterior sides, the posterior side being the broader.

Ultimate leaves abruptly pinnate with one pair of very shortly petiolulate leaflets, articulated with the petiole; leaflets obliquely oblong, or subfalcate, acuminate, obtuse, unequal-sided, glabrous, coriaceous, light or deep green, densely dotted with immersed glands on the under side, with a row of submarginal, larger, suboblong or oval ones, all of which are translucent when held up to the light; petioles thickened at the base and apex; stipules oblong-lanceolate, acute, pale green, with translucent glands and a finely ciliate margin; caducous.

Tribe Cynometreæ.

Copaifera officinalis, *L.*

Hypocotyl aerial, erect, terete, stout, covered with short, minute hairs, soon becoming woody and deep brown, 4–5 cm. above ground.

Cotyledons aerial, but very fleshy, oblong, obtuse, entire, sessile, shortly auricled at the base, rounded on the back, flat on the inner

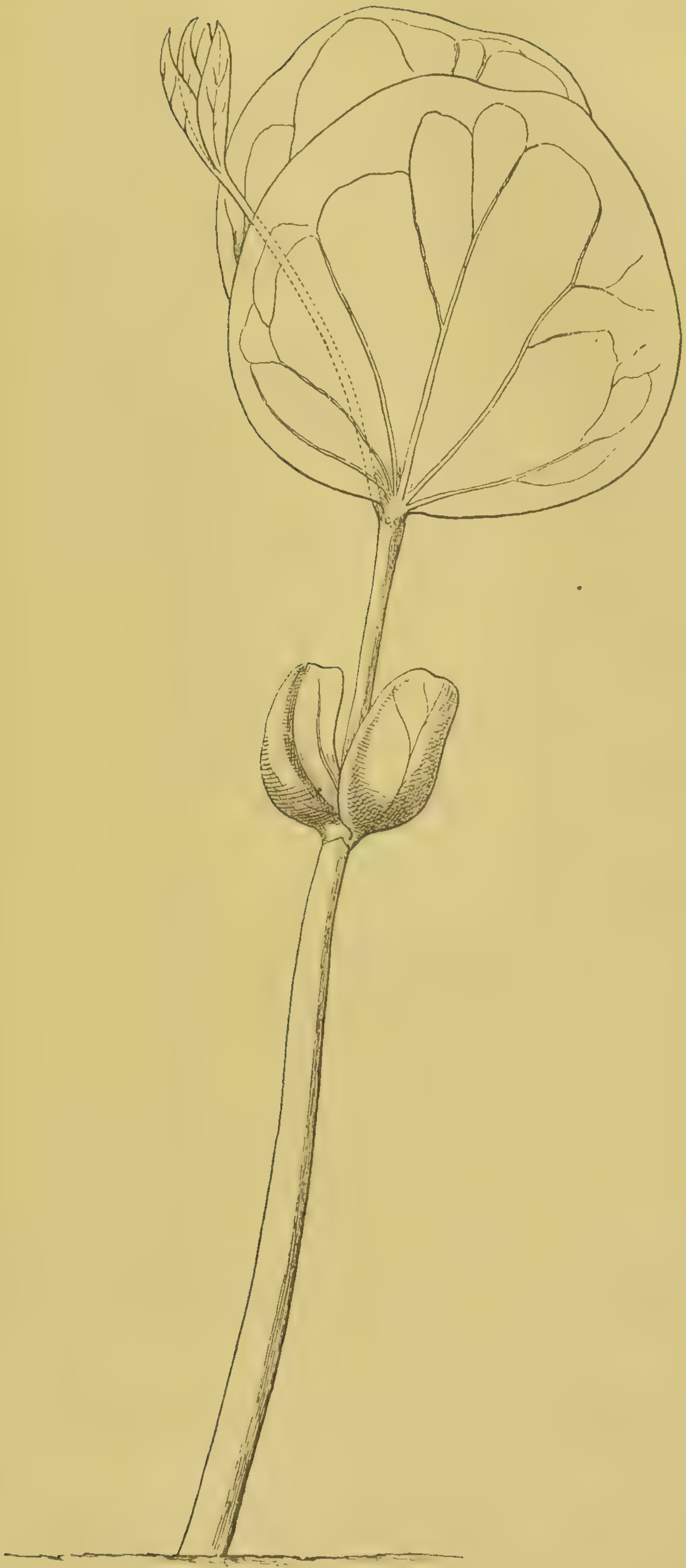

FIG. 805.—*Hymenæa Courbaril.* Nat. size.

face or becoming concave by shrivelling, 1·4–1·6 cm. long, 8–10 mm. wide, reddish or tinged with yellow.

Stem erect, terete, green, densely covered with short incurved hairs, soon becoming woody; 1st internode 3·5–4 cm. long, together with the hypocotyl constituting the whole of the first season's growth and terminating in a small bud that appears to be lateral owing to the size of the first leaf.

Leaves compound, abruptly pinnate, cauline, alternate, stipulate, petiolate, evergreen, glabrous, full of pellucid glands, leathery, penninerved, reticulate, bright green and shining; stipules small, deciduous; petiole very short, stout, cylindrical, finely pubescent between the leaflets like the midrib and the petiolules.

No. 1. Of three pairs of lanceolate, obtuse, falcate leaflets, oblique on the posterior side, and more or less cut away on the anterior side at the base, especially the uppermost pair.

SUBORDER MIMOSEÆ.

TRIBE ADENANTHEREÆ.

Adenanthera Pavonina, *L.* (fig. 306).

Hypocotyl soft, succulent, erect, terete, glabrous, green, 1·5 cm. long, afterwards woody.

Cotyledons sessile, erect and clasping the stem with subsagittate auricles at the base, fleshy, thick, margin slightly undulate, olive green, with buds in their axils.

Stem erect, terete or substriate, glabrous, green, ultimately woody; 1st internode 2·4 cm. long.

Leaves compound, cauline, alternate (first two opposite), stipulate, petiolate; stipules minute, glandular.

Nos. 1 and 2. Pinnate; leaflets alternate, lanceolate-oblong, acute or cuspidate, entire, glabrous, pale green, largest about the middle of the leaf, and gradually smaller to each end; petiole subterete, channelled on the upper side, 8 mm. long; rachis of leaf terete, slightly channelled on the upper side at the base, ending in a slender, filiform point beyond the uppermost leaflet; point 4 mm. long.

No. 3. Alternate.

Nos. 4–6. Alternate, paripinnate; leaflets alternate.

Nos. 7–9. Bipinnate with two pairs of opposite pinnæ; apex of rachis abrupt; leaflets alternate.

No. 10. Bipinnate, abrupt, with three pairs of pinnæ; leaflets alternate, unequal in size, rotund or oval at the base of pinna, oblong, obtuse and minutely cuspidate on upper part of pinna, pale green, glabrous; apex of pinnæ abrupt; petiole terete, subchannelled on the upper side, 2·8 cm. long; rachis between the first and second pair of pinnæ 1·7 cm. long; between second and third pair 1·9 cm. long.

Ultimate leaves bipinnate and large, with three to four pairs of pinnæ.

Prosopis juliflora, *DC.*

Hypocotyl erect, terete, suffrutescent, slender, pale green becoming brownish, 1·6 cm. above the soil.

Cotyledons broadly oblong, obtuse, subsessile, falling away rather early, glabrous.

Stem erect, suffrutescent, terete, glabrous, subflexuous, wiry; 1st internode 1·75 mm. long; 2nd 6 mm.; 3rd 4 mm.; 4th 5·5 mm.; 5th 3 mm.; 6th 4 mm.; 7th 6·5 mm.

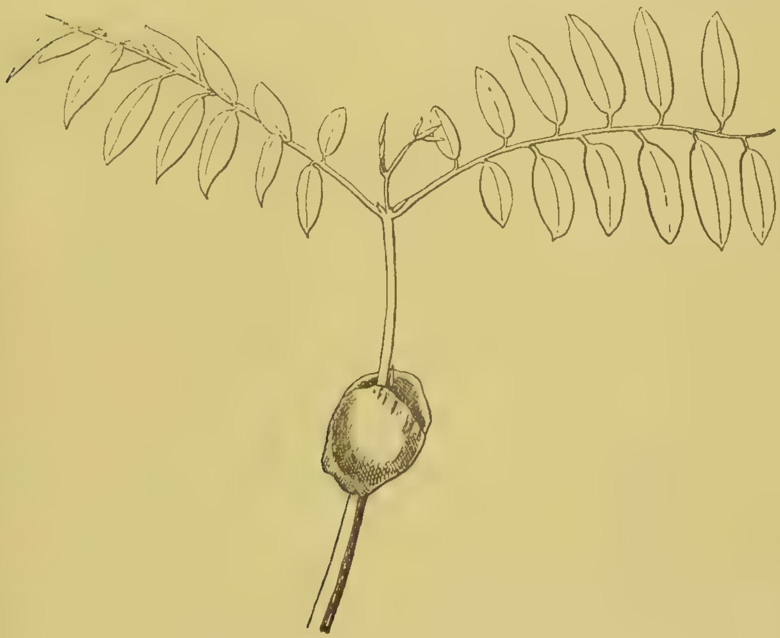

FIG. 306.—*Adenanthera Pavonina.* Nat. size.

Leaves compound, cauline, alternate, stipulate, petiolate, glabrous, glaucous-green; petioles slender, terete, almost filiform, glabrous, glaucous; stipules subulate, acute, pale green, glabrous.

No. 1. Abruptly pinnate with four pairs of oblong, obtuse, apiculate leaflets, the basal and uppermost pairs small.

No. 2. Abruptly bipinnate with one perfect pinna of four pairs of oblong leaflets and an abortive pinna; petiole terminating in a small subulate point between the pinnæ.

Nos. 3–8. Bipinnate with one pair of pinnæ; pinnæ abruptly pinnate; leaflets opposite, oblong, obtuse, apiculate, folding up face to face and imbricating longitudinally on their own rachis when the temperature is low or towards evening.

Dichrostachys cinerea, *Wight et Arn.*

Hypocotyl woody, erect, terete, thinly pubescent, soon losing its epidermis and becoming greyish.

Cotyledons oblong-ovate, obtuse, cordate and three- or faintly five-nerved at the base, deep subglaucous-green above, paler beneath, glabrous, erect, very shortly petiolate, 1 cm. long, 8 mm. broad.

Stem woody, erect, terete, pubescent, pale green; 1st internode undeveloped; 2nd 1·25 cm long; 3rd 1·6 cm.; 4th 1·1 cm.; 5th 1·15 cm.; 6th 9 mm.

Leaves abruptly uni- to bi-pinnate, cauline, alternate, stipulate, petiolate, ciliate on the margins of the leaflets, deep glaucous-green above, glaucous beneath; leaflets folded upwards and forwards, imbricate with lower ones always outside the upper when the temperature is low; petioles subterete, channelled above, pubescent, articulated with a large swollen base, excurrent between the pinnæ with a small subulate point; rachis with a small cylindrical gland on the upper side between each pair of pinnæ; stipules slender, subulate, attenuate.

No. 1. Pinnate with about ten pairs of opposite, linear-oblong, acute leaflets.

No. 2. Bipinnate with one pair of pinnæ.

No. 3. Bipinnate with two pairs of pinnæ.

No. 4. Ditto.

No. 5. With three pairs of pinnæ.

No. 6. With four pairs of pinnæ; leaflets linear-oblong or oblong, acute, fewer than those of the four leaves immediately below; lower pair of pinnæ unequal, one pinna linear-oblong, acute, undivided, the other pinna divided into four leaflets on the posterior side, and undivided on the anterior side or that next the rachis.

This reversion is pretty frequent.

TRIBE EUMIMOSEÆ.

Leucæna glauca, *Benth.* (fig. 307).

Hypocotyl rather woody, about 2·5 cm. long and 1–1·5 mm. thick, terete, with a corky collar just above the surface of the ground, pubescent, whitish-green.

Cotyledons with short, connate, pubescent petioles, 1·5 cm. long, 1 cm. broad, and 1 mm. thick, oval or obovate, sagittate at the base, rounded at the apex, entire, slightly convex, five-nerved, glabrous on both sides, dark green above.

Stem erect, herbaceous, terete, glabrous, dark green; 1st internode 1 cm. long, and 1 mm. thick; 2nd shorter and thinner.

Leaves. — No. 1. Abruptly pinnate, about 4 cm. long and 2 cm. broad; leaflets linear-lanceolate, oblique, in about seven pairs, obscurely nerved and veined, thin, bright green above, paler below; leaflets 1 cm. long and 2–3 mm. broad.

No. 2. Abruptly bipinnate, petiole 1·5 cm.long, ·5 mm. thick, ending in a setaceous mucro; primary pinnæ two, about 2 cm. long and 1·25 cm. broad, with about six pairs of secondary ones; the latter subsessile, 6–8 mm. long and 2 mm. broad, otherwise like those of No. 1.

Nos. 3 and 4. Similar to No. 2.

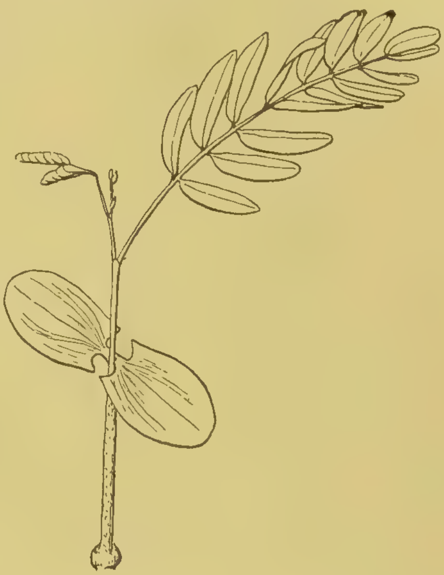

FIG. 307.—*Leucæna glauca.* Nat. size.

TRIBE ACACIEÆ.

Acacia Burkittii, *F. Muell.* (fig. 308).

Hypocotyl suffrutescent, erect, glabrous, pale green, suffused with purple at the base, 5·5 cm. above the soil, 2 mm. thick.

Cotyledons foliaceous, broadly triangular, obtuse, deeply auricled at the base, sessile, with half-ovate auricles, convex above, and deep subglaucous-green, rigid and fleshy, pale beneath with numerous irregular tortuose ridges along the middle, none of which are half the length of the leaf.

Stem succulent, ultimately fruticose, terete, stout immediately above the cotyledons, then suddenly becoming slender, pubescent with somewhat adpressed curved hairs, pale green; 1st internode 1·5 mm. long; 2nd 4 mm.; 3rd 1·1 cm.; 4th 1·35 cm.; 5th 1·15 cm.

Leaves compound, cauline, alternate, stipulate, petiolate, bright green above, paler beneath; petioles subterete, channelled above, densely pubescent as well as the rachis of pinnæ when young, less so when older; stipules subulate, acute, free.

Nos. 1 6 inclusive. Bipinnate with one pair of pinnæ and numerous pairs of opposite, oblong, or obovate-oblong, minutely apiculate or subacute, shortly petiolulate leaflets; petiole excurrent between the pinnæ, with a subulate slender point; rachis of pinnæ excurrent in the form of a small subulate point.

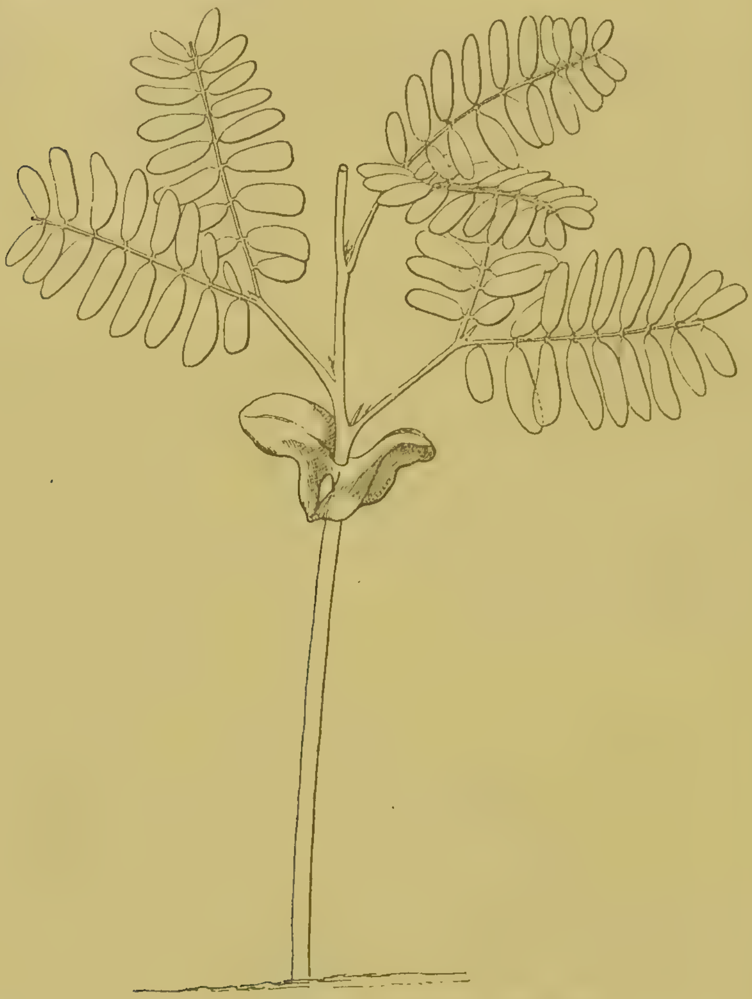

Fig. 308.—*Acacia Burkittii.* Nat. size.

Acacia Oswaldi, *F. Muell.*

Hypocotyl as in last species, substriate, 1·3 cm. to 2·7 cm. above ground, 1 mm. thick.

Cotyledons obovate-oblong, obtuse, auricled or sagittate at the base, sessile, thickened at the margin, deep green above, paler beneath and wrinkled longitudinally, glabrous, fleshy, 1 cm. long, 6 mm. broad.

Stem suffrutescent, erect, terete, glabrous pale green; internodes differing in length in different individuals.

Plant No. 1.—1st internode 3 cm. long; 2nd 2 mm.; 3rd 1·5 mm.; 4th 2·25 mm.; 5th 7·5 mm.; 6th 3 mm.; 7th 1·1 cm.; 8th 5 mm.; 9th 4 mm.; 10th 5·5 mm.

Plant No. 2.—1st internode 1·5 mm. long; 2nd 1 mm.; 3rd 5 mm.; 4th 1·15 cm.; 5th 5 mm.

Leaves compound and abruptly pinnate or reduced to phyllodes, cauline, alternate, stipulate, petiolate, glabrous; stipules small, slender, subulate, acute.

Plant No. 1.—No. 1. Pinnate, with one pair of pinnæ and excurrent at the apex to a filiform point; leaflets oblong, obtuse, subcuspidate.

No. 2. Dropped or broken off.

No. 3. Pinnate with three pairs of leaflets.

No. 4. With two small, ovate, acute, and one oblong leaflet; petiole laterally compressed.

Nos. 5–10. Reduced to lanceolate-oblong, acute phyllodes with their edges placed vertically, equally deep green on both sides, and longitudinally multinerved.

Plant No 2.—Nos. 1 and 2. With three pairs of oblong subcuspidate leaflets with subinvolute margins and unequal at the base on the posterior side.

No. 3. With two pairs of leaflets; petiole slightly compressed laterally and in a less degree than those of Nos. 1 and 2.

No. 4. With one pair of leaflets and a strongly projecting rachis; petiole laterally compressed, linear-lanceolate with its edges vertical.

No. 5. Reduced to a phyllode.

Acacia verticillata, *Willd.* (fig. 309).

Hypocotyl erect, terete, green, soon becoming woody.

Cotyledons obovate, oblong, obtuse, subfleshy, deep green and shining, 4·5 mm. long; 3·5 mm. broad.

Stem woody, erect, terete, ribbed and furrowed or deeply striate, closely and minutely tuberculated, very sparsely pubescent, bright green at least when young; 1st internode undeveloped; 2nd 3 mm. long; 3rd 6 mm.; 4th 6·5 mm.; 5th 2·5 cm.; 6th 1·6 cm.; 7th 8·5 mm.; 8th 7 mm.; 9th 4·5 mm.; 10th 3 mm.

Leaves at first pinnate, then bipinnate, then reduced to phyllodes, cauline, alternate (the phyllodes more or less verticillate, sometimes scattered), stipulate, petiolate, deep glaucous-green above, glaucous beneath (phyllodes deep green like the petioles of the leaves), glabrous except the slightly pubescent petioles and midrib; petioles laterally compressed but less so than the phyllodes, deep green and shining, and projecting beyond the pinnæ with a subulate acute aristate point; stipules small, subulate, acute, or lanceolate and aristate, reduced to small dark hairs where the phyllodes are verticillate or suppressed, but usually well developed where these are scattered.

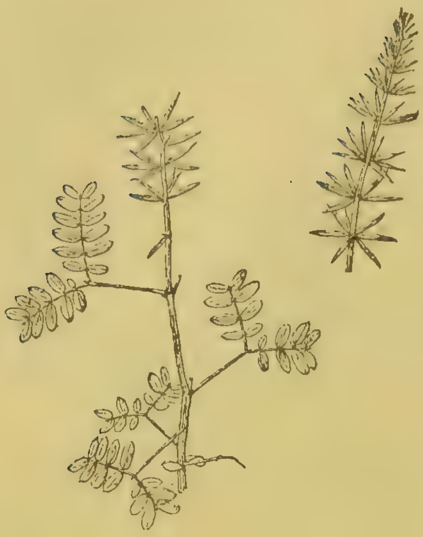

Fig. 309.—*Acacia verticillata.* Half nat. size.

No. 1. Pinnate with two pairs of leaflets.

Nos. 2–5 inclusive. Bipinnate with one pair of pinnæ; leaflets varying from obovate-oblong to oblong (the commoner form), obtuse, aristate, folding upwards and forwards face to face at night.

No. 6 (in specimen sketched). Reduced to a small laterally compressed phyllode, about 8 mm. long.

Nos. 7–11. Forming a half whorl of phyllodes.

Nos. 12–16. Forming a broken or interrupted whorl.

No. 17. A solitary phyllode.

Nos. 18–23. A whorl of phyllodes.

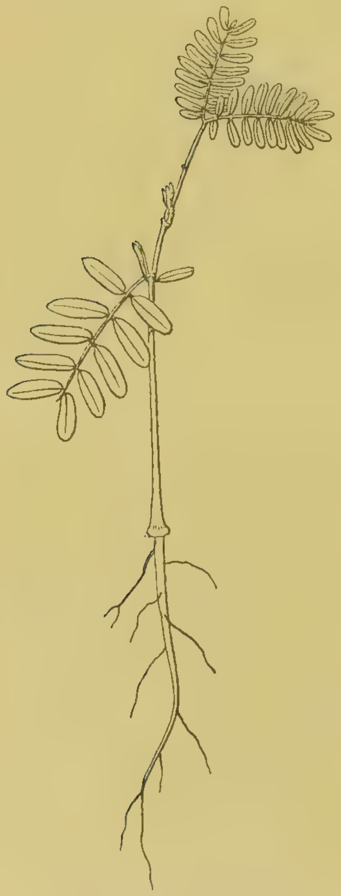

Fig. 310.—*Acacia dealbata.* Half nat. size.

Acacia dealbata, *Link.* (fig. 310).

Primary root tapering, with a few colourless lateral rootlets.

Hypocotyl terete, firm, glabrous, brownish, 3–4 cm. long, ·5–1 mm. thick.

Cotyledons sessile, 6 or 7 mm. long, 1·25 mm. in diameter when rolled up, 3 mm. when opened out, revolute, oblong, entire, obscurely nerved on the outer side, with a very prominent midrib below, thin, light green.

Stem firm, terete, but slightly uneven and downy, brownish-green; 1st internode undeveloped; 2nd about 1 cm. long, ·5–1 mm. thick.

Leaves.—No. 1. Pinnate; leaflets linear-oblong, obtuse, entire, sessile or subsessile.

No. 2. Bipinnate; leaflets linear, obtuse, entire.

Acacia acanthocarpa, *Willd.*

Hypocotyl 2·5 mm. long, light green or colourless.

Cotyledons thick, fleshy, broadly oblong, entire, slightly cordate at the base, obtuse, shortly petiolate, glabrous, trinerved.

Stem erect, terete, herbaceous at first, ultimately woody; 1st internode 2–3 mm. long, finely pubescent.

First leaves compound, abruptly pinnate, petiolate, stipulate, alternate, cauline; leaflets opposite, shortly petiolulate, entire, oval-oblong, obtuse, eight in first leaf; the petiole and petiolules are slightly hairy.

NOTE.—The cotyledons are often three in number; out of eleven plants four had three cotyledons.

TRIBE INGEÆ.

Pithecolobium Saman, *Benth.*

Hypocotyl woody, erect, terete, glabrous, 6·5 cm. long, 2 mm. thick, pale green.

Cotyledons (dropped).

Stem becoming woody, erect, terete, striate, densely hairy and almost woolly on the younger parts, pale green; 1st internode 2·5 mm. long; 2nd 9 mm.; 3rd 1·1 cm.

Leaves cauline, compound, alternate (first two opposite), petiolate, stipulate and stipellate, ciliate, pubescent beneath and on the petioles, ultimately becoming glabrous except the petioles and apparently the margin.

No. 1. Simply and abruptly pinnate, with three pairs of opposite leaflets; lowest pair lanceolate, acute, slightly unequal at the base; second pair oblong, obtuse, cuspidate; third pair obovate, oblong, obtuse, cuspidate, all petiolulate; stipules free, subulate, acute.

The primary rachis of the first leaf frequently ends in a small, lanceolate, acute leaflet, thus making the leaf imparipinnate.

No. 2. Bipinnate, consisting of one pair of pinnæ or primary divisions, and terminating abruptly; pinnæ of two pairs of leaflets with sometimes an odd one at the base laterally, terminating in a subulate acute mucro, stipellate at the base; leaflets unequal in size, oval, oblique, obtuse, or subcuspidate, unequal at the base; one of the basal ones is frequently very small, namely the one on the basal, anterior side of the pinna.

No. 3. Similar to No. 2.

N.B.—The odd leaflet on the posterior basal side of the pinna is accounted for by the suppression of the corresponding anterior one.

ROSACEÆ.

Benth. et Hook. *Gen. Pl.* i. 600.

Fruit and Seed.—The carpels of which the ovary is composed in this Order vary from one to many, and are free or in some genera more or less connate and adherent to the tubular or variously concave receptacle. A monocarpellary type is represented by Prunus, while a two- to five-celled ovary is characteristic of the tribe Pomeæ.

Polycarpellary ovaries occur in Rubus, Potentilla, Fragaria, Geum, Spiræa, Rosa and others. Each carpel is one-celled or spuriously two-celled. The ovules are generally geminate, pendulous and anatropous, and superposed; and in this case the raphe is ventral and the micropyle superior. They are, however, solitary in the Potentilleæ, Roseæ, Poterieæ, and Neuradeæ. In some cases they are ascending with a dorsal raphe and inferior micropyle, as in the Chrysobalaneæ, Quillajeæ and others. Numerous ovules occur in Pyrus and others of the Quince type and in Spiræa. The fruit is extremely variable, being drupaceous in the Chrysobalaneæ, Pruneæ, and Rubeæ; in the latter the torus is elevated and conical. It is follicular in many of the Spirææ, consists of achenes in the Potentilleæ, Poterieæ, and Roseæ, and forms a pome in the Pomeæ. The receptacle of Fragaria is of considerable size and pulpy or succulent, while in Rosa[1] it is urceolate, fleshy, and termed a 'hip,' while in the Poterieæ it is dry, concave, cup-shaped or almost urceolate. In the Pomeæ it is fleshy and adherent to the ovary; and in certain cases is capsular, dehiscing by valves. When greatly enlarged, as in Fragaria, Rubus, Rosa, some species of Potentilla and others, the carpels are numerous and small. In drupaceous and pomaceous fruits the endocarp is bony or woody, crustaceous or cartilaginous.

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[1] There is some difference among botanical writers as to the use of these terms in the Rosaceæ, the concave receptacle being sometimes regarded as part of the calyx, and styled calyx-tube.

The seed is erect or pendulous in accordance with the ovule, with a membranous or coriaceous testa, occasionally winged. Endosperm is wanting in most cases, but not in all. The embryo is almost absolutely straight, with fleshy plano-convex cotyledons, resembling the almond, though in most cases very small. Rarely are the cotyledons large and foliaceous. The micropyle is close to the hilum, and the short radicle points to it.

All the seeds coming under notice are entirely exalbuminous, and their embryos amygdaloid. They may be classified according to relative size, character of the fruit, or peculiarities in the development of the receptacle. For instance, the species of Prunus, including the old genera Persica, Amygdalus, Armeniaca, Cerasus and Laurocerasus, all have very large amygdaloid embryos and a bony endocarp, and may be considered as the typical representatives of the Order as far as shape and general features of the seed and embryo are concerned. A very small type is met with in Spiræa, and endosperm occurs in some genera belonging to the same tribe, such as Neillia, Stephanandra, Gillenia, and Neviusa, as well as in Canotia, Eucryphia, and Euphronia belonging to the Quillajeæ.

The separate drupels of Rubus Balfourianus may be compared to those of Prunus on a small scale, and similarly the embryo which conforms closely to the shape of the seed and that again to the interior of the endocarp which is indehiscent and bony. The achenes of Potentilla insignis are laterally compressed, ridged and somewhat oblique, causing the embryo to assume the same general outline and the radicle to be bent on one side, a very unusual circumstance in the Order. The fruit of the Poterieæ consists of one to three achenes enclosed in the concave, urceolate or closed receptacle. When only one achene is enclosed it conforms to the interior of the cavity, but when two or three share the space they are more or less angled by mutual pressure. The receptacle of Agrimonia

Eupatoria is turbinate and terminated by a great number of hooked processes. That of Acæna ovalifolia (fig. 318) is small, elliptic, and furnished below the apex with two to four strong, spine-like processes with barbed tips. The elliptic receptacle of Acæna myriophylla is covered all over with smaller barbed processes. That of Poterium Sanguisorba (fig. 320) is ovoid and smooth. The cotyledons of all the four types belonging to the Poterieæ are slightly auricled at the base so as to fill the space in the seed while at the same time accommodating the radicle. In the tribe Roseæ we have a higher development of what occurs in the Poterieæ unless we regard the latter as degraded forms of the Rosaceæ, which is not unlikely, and is, indeed, suggested by several circumstances in addition to those affecting the fruit. The achenes of the different species of Rosa are very numerous and included in an urceolate, ultimately baccate receptacle. The seed in the tribe Pruneæ is protected by a bony endocarp; but in the Roseæ the enlarged receptacle only is fleshy, while the whole of the ovary wall in Rosa is bony, suberous, or coriaceous in order to protect the seeds. The achenes are covered with short bristly hairs along the dorsal suture in many species. The embryo resembles the Almond in miniature, and the seed being solitary in each achene conforms to the interior of the latter. The seeds and embryos in the tribe Pomeæ have much in common with all of the foregoing, but they vary somewhat in different genera and species according to modifications of the true fruit or walls of the ovary. In Rosa, as already noted, the achenes or fruits are quite free from one another and from the surrounding hollow receptacle. The carpels in the Pomeæ vary from two to five and are generally quite free from one another or ultimately separable, but they are closely adnate to or united with the inner surface of the greatly enlarged, fleshy receptacle. We find two very distinct modifications of the ovary walls of Pyrus. Those of P. Malus are cartilaginous, those of P. communis often very thin and easily broken, while in P. Aria this is always the case. P. germanica and Mespilus grandiflora, often classed together under the genus Mespilus, have a bony endocarp, and the shape of the seed is modified by it.

This may be seen by reference to Cratægus Pyracantha, where a similar condition prevails. The globose fruit consists of five carpels surrounded by the fleshy receptacle. The walls of the carpels become greatly ossified or, properly speaking, lignified and thickened; and seeing that each carpel or pyrene constitutes the fifth part of a sphere, they are trigonous or wedge-shaped in transverse section, and modify the shape of the seed and embryo in conformity with their own. The loculi in the fruits of the species of Pyrus generally are proportionately large so that they do not affect the shape of the seed. In Pyrus Cydonia, P. japonica, and P. chinensis, the ovules, and afterwards the seeds, are very numerous in each loculus, a most unusual circumstance in the Order.

Seedlings.—As in the seeds so in the seedlings we find a great similarity prevailing amongst the cotyledons of different species and genera throughout the Order. The embryo is amygdaloid, varying for the most part in size, dependent upon the size of the seed, and that again upon the size of the endocarp or the achene. The cotyledons in the seedling stage are nearly all of the same general outline, varying between oval and oblong. They are for the most part shortly petiolate with a slender, rarely a broad petiole, and being either thick or opaque they do not often exhibit much of the venation beyond the midrib. Those which are more or less deeply emarginate form a second type; while a third form has the lamina cordate at the base. Taking the type, which varies between oblong, oval, and suborbicular, two species might be singled out as extreme modifications. These are the Cherry and Rosa berberidifolia (fig. 322). The first has spathulate-oblong, fleshy, entire cotyledons with glands at the base. The second has narrowly oblong, glandular-ciliate cotyledons with a rather broad petiole. The Spiræas, having generally very small seeds, have small cotyledons. S. callosa (fig. 311) represents one of the shrubby tribe. The primary leaves are small and vary from cuneate to broadly ovate. The ultimate leaves are lanceolate and unequally serrate.

The cotyledons of Rubus are moderately large, owing to the size of the seed. Those of Rubus phœnicolasius (fig. 312) are shortly oblong, while those of R. rugosus are broadly oval.

Both show a very gradual evolution of the leaves, but particularly R. phœnicolasius where the first is ovate, the second and third reniform, and the fourth to the seventh inclusive are oblong-cordate, and more or less lobed.

The Potentilleæ have mostly small seeds and small cotyledons, but some striking variations in this respect may be found amongst the species of Geum as represented by G. Freemontii (fig. 313) and G. coccineum, the latter of which has broadly oblong trinerved cotyledons. G. urbanum is intermediate between these extremes. All have pinnate leaves ultimately, while the first one is reniform or triangular with many intermediate forms in the seedling stage. The fourth leaf of G. coccineum is cordate, and the fifth lyrate-pinnatifid. The cotyledons of all the species of Potentilla observed are small and vary from oval to oblong-oval and suborbicular. As far as the leaves are concerned two very distinct types may be noticed, namely, those with pinnate leaves such as Potentilla anserina (fig. 316), P. fulgens (fig. 315), and P. bifurca (fig. 317), and those with digitate leaves represented by P. argyrophylla and P. reptans (fig. 314). The species of Rosa conform to the general type in having oval or oblong cotyledons. R. berberidifolia, as already mentioned, is an extreme type. The cotyledons are generally moderately large, and in R. moschata this is particularly the case; they are also minutely emarginate, trinerved and ciliate. All the leaves of R. berberidifolia are cuneate, simple and doubly serrate. The first three of R. moschata are trifoliolate. More typical examples are met with in R. rugosa and R. macrocarpa. The cotyledons are oval, the first leaf cuneate and simple, the second trilobed or trifoliolate, while a number of succeeding ones are trifoliolate.

The members of the tribe Pomeæ have moderately large cotyledons varying from oblong-oval to obovate in conformity to the seeds containing them. They are generally very shortly petiolate, sometimes subsessile, and more or less evidently trinerved though rather opaque. Pyrus Aucuparia (fig. 323) shows the trinerved character. The first leaf is ovate and trifid; the second tripartite, and succeeding ones pinnate. The cotyledons of Cratægus Oxyacantha (fig. 324) and C.

mexicana are also trinerved. The primary leaves of the first named are trifid, gradually increasing in size; the first two of the latter are oblong, succeeded by two other oblong-elliptic ones. The cotyledons of Cotoneaster Simonsii (fig. 325) agree strictly with the type. The leaves are ovate and entire from the first to those of the adult.

The second group includes a number of species belonging to different genera, the cotyledons of which do not differ materially from those of the last group except in being more or less deeply emarginate. This type is well represented by Spiræa opulifolia, having oblong-obovate, emarginate cotyledons. The first leaf is broadly ovate, succeeded by two broader trifid ones; all are palmately trinerved. The cotyledons of Agrimonia viscidula are transversely oblong or suborbicular, rather deeply emarginate, and cordate at the base. The first leaf is cordate-orbicular, and the second one pinnately trifoliolate. The cotyledons of Eucryphia cordifolia are broadly-oblong, trinerved, but very slightly emarginate. The first four leaves are oblong. Rosa moschata might have been placed here, but its cotyledons are only slightly emarginate. The same might be said of Rubus thyrsoideus, which has broadly oblong or oval, minutely emarginate, glandular-ciliate cotyledons. The first three or four leaves are broadly ovate, and others show gradual evolution.

The most distinct divergence from the type is that found in a number of closely allied plants constituting the tribe Poterieæ, and therefore forming a very natural group. The cotyledons are broadly oblong and short, or oblong-orbicular, deeply notched or cordate at the base, slightly emarginate, and petiolate. This type is well exemplified in Acæna myriophylla (fig. 319). The first leaf is pinnately five-foliolate, and the ultimate leaves pinnate, pinnatisect with linear or subulate acute segments. To this may be added A. ovalifolia, Agrimonia Eupatoria, and Poterium Sanguisorba (fig. 321). The latter shows numerous incurved, slender veins proceeding from the midrib of the cotyledons. The two primary leaves are trifoliolate, the ultimate ones imparipinnate with numerous orbicular or shortly oblong, deeply toothed leaflets. The basal notch is due to the cotyledons becoming prolonged at the base in order to occupy the available space in the bluntly pointed upper end of the seed, while they at the same time accommodate the stout radicle in the sinus. Alchemilla aphanoides, also belonging to the Poterieæ, has oval, obtuse, entire, petiolate cotyledons, with the petioles connate and sheathing at the base, and therefore agrees with the prevailing type of cotyledon in the Order rather than with its allies. The first leaf is trifid with entire segments; the second more deeply so with the middle lobe tridentate; and the next three are tripartite with cuneate, variously toothed segments.

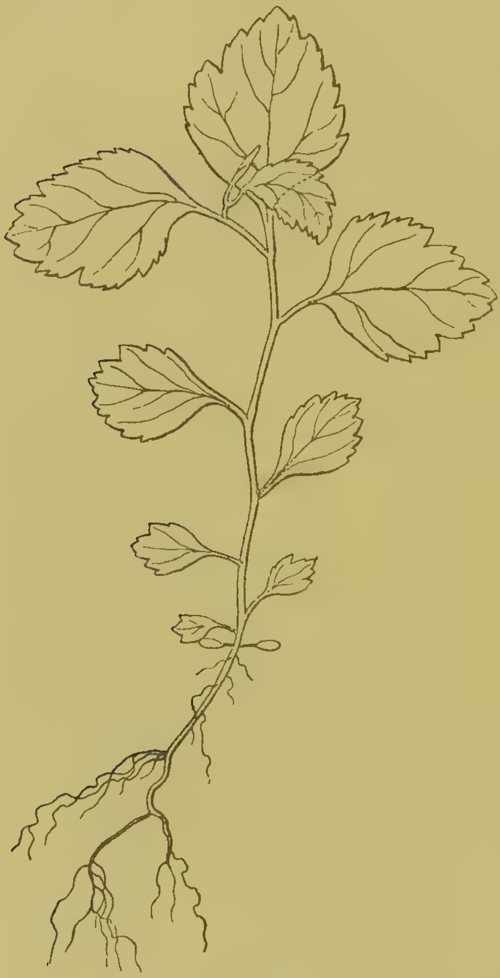

Fig. 311.—*Spiræa callosa.* Nat. size.

Spiræa callosa, *Thunb.* var. (fig. 311).

Primary root slender, flexuous, giving off secondary rootlets, yellowish.

Hypocotyl erect, terete, or ascending, short, glabrous, pale green, 3–6 mm. long, very slender.

Cotyledons small, petiolate, glabrous, pale green; lamina 2·5 mm. long, 1·5 mm. broad; petiole 1·5 mm. long.

Stem shrubby, wiry erect, flexuous, pubescent with upcurved and incurved hairs, pale green, soon becoming yellowish, ultimately brown; 1st internode 1·25 mm. long; 2nd 2 mm.; 3rd 5 mm.; 4th 7 mm.; 5th 7 mm.; 6th 1 cm.; 7th 6·5 mm.; 8th 5 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, sparsely pubescent, ultimately subglabrous except on the principal nerves and the margin; stipules obsolete or very caducous; petioles short, shallowly channelled on the upper side, pubescent.

No. 1. Small, cuneate, tridentate.

Nos. 2 and 3. Cuneate and serrate along the upper half.

No. 4. Subelliptic, cuneate at the base, serrate along the upper half.

No. 5. Elliptic-cuneate, unequally serrate along the upper half.

No. 6. Broadly ovate, obtuse, becoming doubly serrate along great part of its length, somewhat oblique at the base and scarcely cuneate, subtrinerved.

No. 7. Ovate, becoming doubly serrate, subtrinerved.

No. 8. Broadly ovate, obtuse or subacute, becoming doubly serrate.

Ultimate leaves lanceolate, acuminate, serrate and doubly so above the middle, with numerous ascending nerves, reticulate, deep green above, glaucous beneath, subglabrous except on the margins and principal nerves.

Spiræa opulifolia, *L.*

Hypocotyl erect, terete, glabrous, green or reddish, 5–7 mm. above the soil, and becoming stouter upwards.

Cotyledons oblong-obovate, emarginate, with two pairs of alternate, ascending, branching nerves, the uppermost incurving and uniting with the midrib under the apical sinus, petiolate, glabrous, rather opaque, and showing the venation best by transmitted light; lamina horizontal or decurved, 5–6·25 mm. long, 3–4 mm. wide; petiole ascending or suberect, channelled above, slightly convex on the back, slightly connate at the base, about 1 mm. long.

Stem erect, two-edged or two-winged by the decurrent edges of the petioles, pale green, soon becoming brown, glabrous, ultimately shrubby; 1st internode 2·25–6·25 mm. long; 2nd 4–5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, alternately or suboppositely penninerved, with the nerves running straight into the tips of the lobes, glabrous and bright green above, paler beneath, shining when young; petioles semiterete, channelled above, widening upwards, slightly winged at the edge on the upper half, glabrous; stipules half-ovate, acuminate, serrated on the posterior side, attached to the very base of the petiole.

No. 1. Broadly ovate, obtuse, palmately trinerved, dentate-serrate, with obtuse, gland-tipped teeth.

Nos. 2 and 3. Trilobulate, dentate-serrate with obtuse, gland-tipped teeth, palmately trinerved with strong alternate nerves above.

Eucryphia cordifolia, *Cav.*

Hypocotyl erect, terete, finely pubescent, 1·5–2 cm. long, reddish.

Cotyledons coriaceous, slightly emarginate, broadly oblong or oval, shortly petiolate, minutely pubescent, dark green above, tinged with red beneath, trinerved.

Stem erect, terete, herbaceous at first, pubescent; 1st internode 2–3 mm. long; 2nd 5–6 mm.

First leaves simple, cauline, opposite, oblong, acute, serrate, shortly petiolate, stipulate, pubescent, glabrous beneath, light green above, subglaucous-green or tinged with red beneath, pinnatinerved; venation very distinct on the under side.

Rubus phœnicolasius, *Maxim.* (fig. 312).

Hypocotyl erect, terete, sparsely glandular-pubescent or subglabrous, green, soon becoming brown and suffrutescent, 5–7 mm. above the soil.

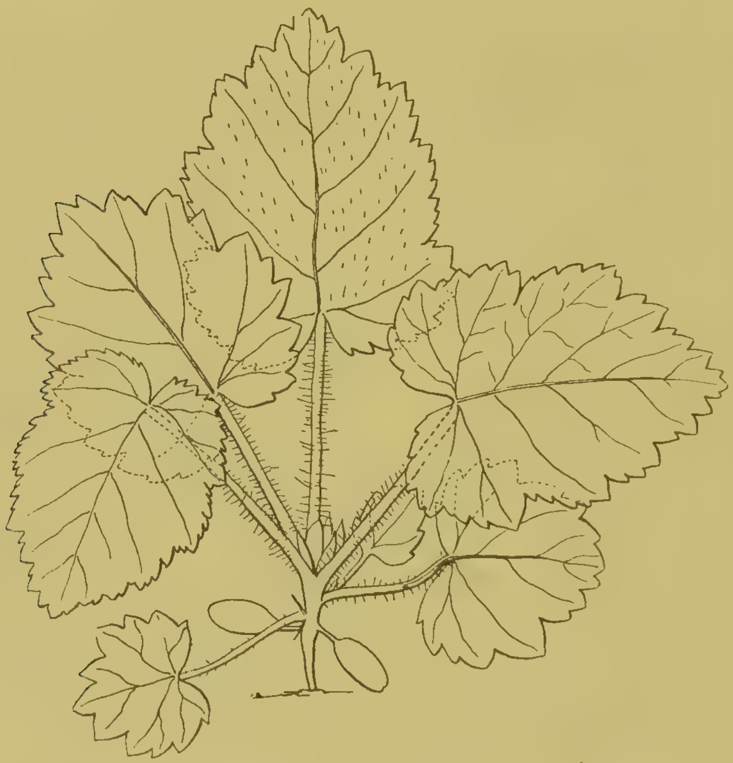

FIG. 312.—*Rubus phœnicolasius.* Nat. size.

Cotyledons petiolate, sparsely glandular-hairy; lamina shortly oblong, obtuse, 7 mm. long, 4·5 mm. broad; petiole slender, tapering to a broadish base, channelled above, 3·5 mm. long.

Stem suffrutescent, erect at first, terete, glandular-hairy, ultimately 8-12 feet long; 1st internode undeveloped; 2nd 1 mm. long; 3rd 1 mm.

Leaves at first simple, ultimately trifoliolate, cauline, alternate, stipulate, petiolate, glandular-hairy on both surfaces, felted beneath with a white tomentum, penninerved with alternate or subopposite nerves; petioles semiterete, channelled above, densely glandular-hairy and glandular-setose, the hairs and setæ of a reddish-purple hue; stipules slender, subulate, attenuate, glandular-hairy.

No. 1. Small, ovate, tridentate, trinerved.

No. 2. Reniform, five-nerved, dentate.

No. 3. Rotund-cordate, obtuse, irregularly dentate.

No. 4. Cordate, irregularly or doubly dentate.

No. 5. Cordate, acute, doubly dentate.

Nos. 6 and 7. Oblong-cordate, acute, doubly dentate or sublobulate with acute teeth.

Ultimate leaves pinnately trifoliolate, pubescent and dark green above, felted with white tomentum beneath, glandular-hairy and setose on the principal nerves; terminal leaflet very large, rotund-cordate, acuminate, trifid and doubly dentate-serrate, strongly penninerved, much reticulate with the stronger nerves running into the lobes or large teeth; lateral leaflets broadly ovate, subacuminate, deeply dentate-serrate, oblique on the posterior side, smaller but otherwise like the terminal one, rather unequal but not cordate at the base.

Leaves on the flowering branches similar to the above, but gradually becoming smaller in size as the inflorescence is approached; petioles terete, very narrowly channelled on the upper side, densely glandular-hairy and setose; stipules subulate or linear, attenuate, slender, shortly adnate to the petioles.

Rubus rugosus, *Sm.*

Primary root tapering, slender, soon becoming wiry, and giving off numerous strong as well as small lateral fibres.

Hypocotyl terete, suffrutescent, thickened upwards, glandular-hairy, 9 mm. long.

Cotyledons shortly and broadly oval, glandular-hairy on the margin, otherwise glabrous, and similar to last species.

Stem as in last species, glandular-setose; 1st internode undeveloped; 2nd 1·5 mm. long; 3rd 6·5 mm.; 4th 3 mm.

Leaves simple, coarsely hairy on both sides and glandular-setose on the nerves and petioles; stipules free, linear, coarsely hairy.

No. 1. Subtriangular, coarsely dentate-serrate.

No. 2. Cordate, coarsely dentate-serrate.

No. 3. Cordate, lobulate, and coarsely dentate-serrate, palmately trinerved.

No. 4. Cordate elongated, lobulate but scarcely pinnatifid, coarsely serrate with mucronate serratures, palmately five-nerved.

Ultimate leaves simple, palmately five- to seven-lobed and -nerved, cordate at the base, closely covered with bulbous-rooted hairs; lobes deltoid, acute or obtuse and more or less rounded, acutely and more or less doubly serrate.

Geum Freemontii, *Hort.* (fig. 313).

Primary root slender, tapering, brownish, with fibrous lateral rootlets, perennial.

Hypocotyl tapering, whitish, glandular-hairy, 4 mm. long.

Cotyledons small, glandular-pubescent, lamina 2·75 mm. long, 2 mm. broad; petiole 2·5 mm. long, dilated and sheathing at the base.

Stem herbaceous.

Leaves radical, simple, ultimately imparipinnate, alternate, stipulate, petiolate, glandular-hairy with hairs of very unequal length; petioles slender, channelled above, and sheathing by means of the stipules; stipules wholly adnate to the petiole by one side.

No. 1. Reniform, palmately five-nerved, with rounded or obtuse teeth.

No. 2. Rotund-cordate, palmately seven-nerved and -fid, with suboval, mucronate lobes.

No. 3. Cordate, palmately seven-nerved and -fid, with oblong-ovate, mucronate lobes.

Ultimate leaves imparipinnate, oblanceolate in outline, hairy on both sides, light green above, paler beneath; leaflets gradually becoming smaller from the apex of the leaf towards the base with occasional minute, lanceolate, entire ones interposed, deeply incise-serrate, cut or subpinnatifid especially on the basal posterior side, with alternate, strong nerves running into the lobes and teeth; terminal leaflet elliptic; the pair below that obliquely ovate, cut away on the anterior basal side; below this the leaflets are ovate, then rotund-ovate, gradually becoming rotund and cuneate at the base; petiole semiterete, channelled on the upper side; stipules hyaline, ciliate, adnate to the petiole, with ovate, acute, free points.

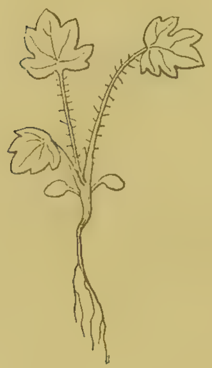

Fig. 313.
Geum Freemontii.
Nat. size.

The cotyledons of G. urbanum resemble those of G. Freemontii.

Geum coccineum, *Sibth. et Sm.*

Primary root and *hypocotyl* very similar to those of last species, but larger and flexuous.

Cotyledons hairy; lamina broadly oblong, obtuse, 8 mm. long, 6 mm. broad; petioles thin, grooved, dilated and connate at the base.

Stem herbaceous and always short, ultimately developing a flower-stem.

Leaves radical, hairy all over; petioles channelled above, semiterete; stipules mostly adnate to the petiole.

No. 1. Triangular, obtuse, crenate-serrate.

No. 2. Reniform, crenate-dentate, three- to five-nerved.

No. 3. Rotund-cordate, palmately five-nerved, crenate-dentate.

No. 4. Cordate, obtuse, crenate-dentate, palmately five-nerved, faintly lobulate, with a small isolated lobe on the petiole.

No. 5. Lyrate-pinnatifid; terminal lobe cordate, obtuse, lobulate; lateral segments small, irregular in size and shape.

Ultimate leaves lyrate-pinnatifid.

Potentilla reptans, *L.* (fig. 314).

Hypocotyl mostly subterranean, tapering into the root, short.

Cotyledons rotund, glabrous; 3 mm. in length and breadth; petiole channelled above, 2·25 mm. long.

Stem never developing, but throwing out long axillary branches or runners, bearing rosettes of leaves at definite points which reproduce the plant vegetatively.

Leaves compound, digitate (first two small, simple), radical and cauline, hairy on both sides; leaflets with alternate, ascending nerves running into the teeth; petioles subterete, channelled above, dilated at the base, hairy, reddish at the base and green upwards; stipules adnate to the petiole for two-thirds their length, reddish, hairy with ovate, acuminate free points.

No. 1. Simple, reniform, three- to five-nerved, toothed.

No. 2. Rotund-reniform, subtruncate at the base, three- to five-nerved, deeply toothed.

Nos. 3–6. Digitately trifoliolate; terminal leaflet cuneate, bluntly and rather deeply toothed on the upper half; lateral leaflets obliquely cuneate, and toothed like the terminal or subbifid, with two strong nerves foreshadowing further division on the posterior or basal side.

Ultimate leaves digitately or subpedately five-foliolate, hairy on both surfaces as well as the petioles, very variable in their size according to the conditions of cultivation; leaflets oblanceolate, serrate, or in vigorous specimens oblanceolate-oblong, coarsely incise-serrate; basal pair obtained by fission from the middle pair, to the petiolules of which they remain attached; stipules attached to the petiole for half their length, with subulate, acuminate, free points.

Potentilla fulgens, *Wall.* (fig. 315).

Hypocotyl subterranean.

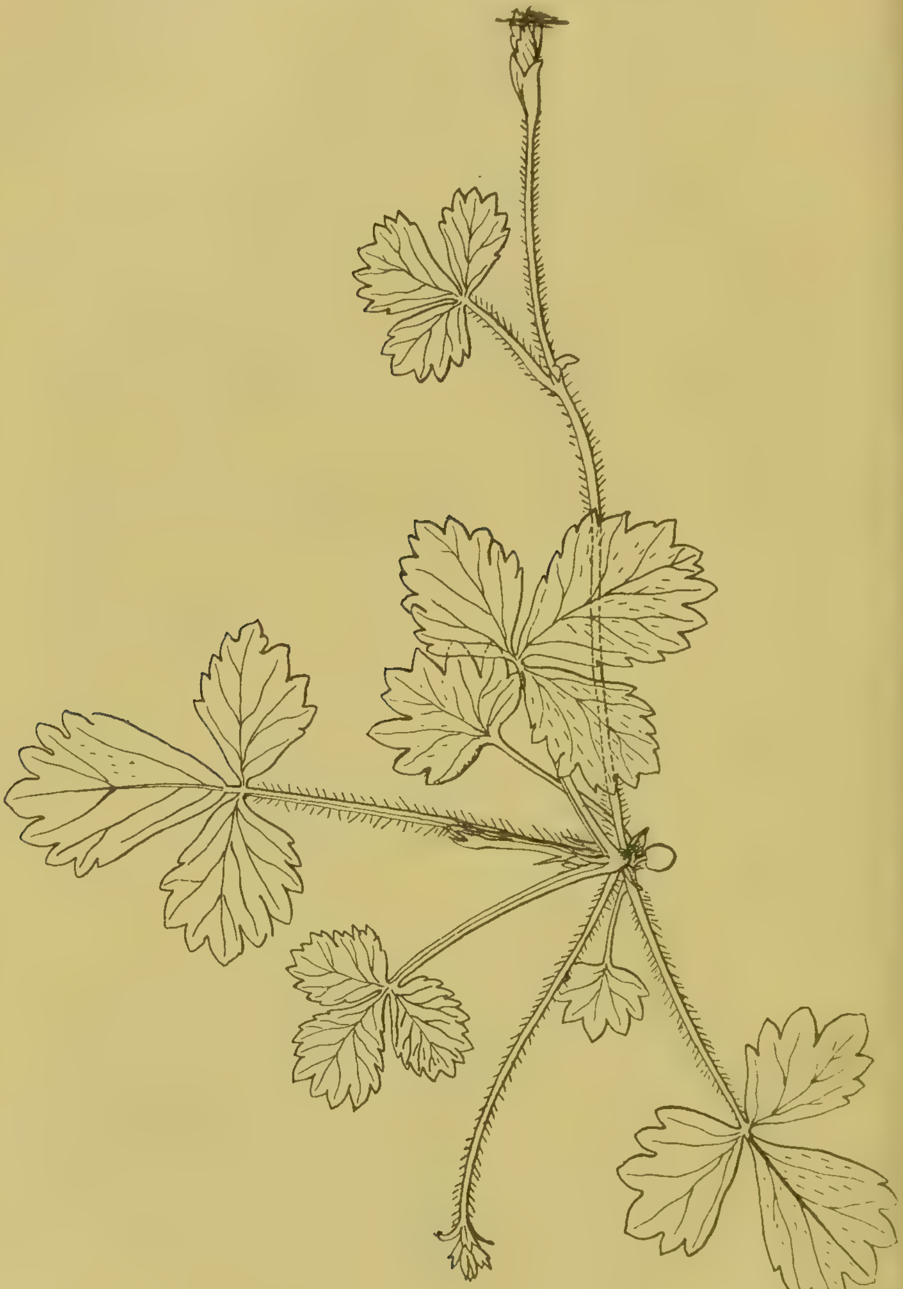

Fig. 314.—*Potentilla reptans.* Nat. size.

Cotyledons small, oval or obovate, 2·5 mm. long, 2 mm. broad ; petiole channelled above, 1·5 mm. long.

Stem herbaceous and elongated when about to flower. No runners present.

Leaves mostly radical, compound (except a few primary ones), alternate, hairy all over; petioles semiterete, channelled above; stipules hyaline and thin, with a green nerve, adnate to the petiole for about three-fourths of their length, with ovate, acute, free points, hairy.

No. 1. Simple, rotund-ovate, dentate-serrate.

No. 2. Simple, rotund, truncate at the base, dentate-serrate.

No. 3. Ternate; lateral leaflets oblong, subdimidiate, serrate on the posterior side, and almost entire on the anterior side, subsessile; terminal leaflet cuneate, serrate at the apex.

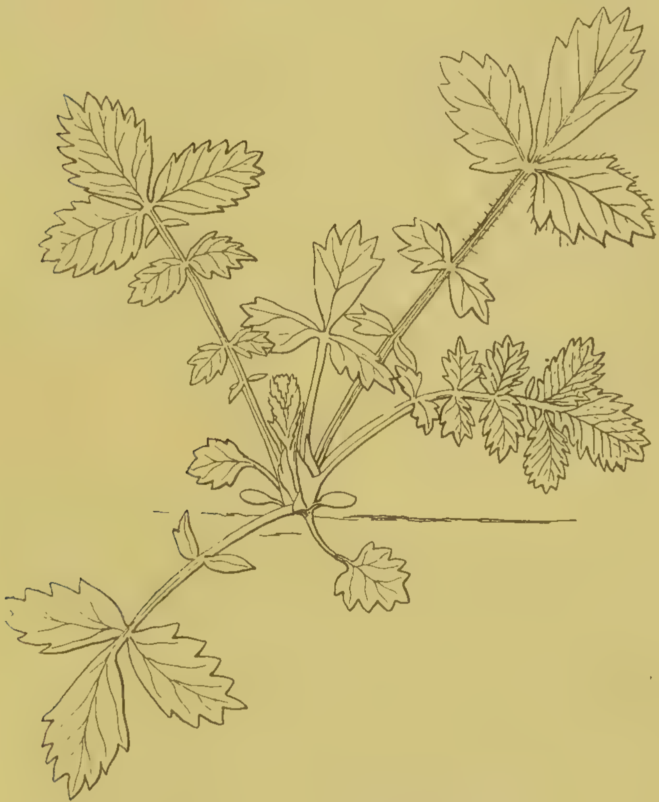

FIG. 315.—*Potentilla fulgens.* Nat. size.

No. 4. Five-foliolate; basal pair of leaflets small, distant from the rest, lanceolate, acute; the other three similar to those of No. 3, but a little more serrate.

No. 5. Seven-foliolate; basal pair small, unequal, subalternate, one lanceolate, acute, the other subovate and trifid; next pair small, ovate, serrate; terminal three similar to those of No. 4.

No. 6. Eleven-foliolate; terminal three large, oblong, serrate; the pair next below minute, lanceolate, acute, entire; next pair larger, ovate, serrate; 4th pair below terminal leaflet small, ovate, serrate; basal pair minute, lanceolate.

No. 7. Eleven-foliolate; second pair below the terminal leaflet very small, lanceolate, acute, entire. All the others serrate and decreasing in size from the terminal one downwards.

Ultimate leaves long, linear-lanceolate, imparipinnate with very numerous leaflets, generally opposite in the upper part of the leaf and alternate lower down, silky on both sides; many of the uppermost leaflets decurrent on the rachis by their posterior basal side, oblong, serrate with long, subulate, acute, serratures; middle ones smaller and not decurrent; lower ones gradually becoming smaller towards the base, ovate and serrate, or the lowermost minute, lanceolate, acute, entire; stipules hyaline and hairy, one-nerved, attached for some distance to the petiole, with the free part oblong-subulate, acute.

Potentilla argyrophylla, *Wall.*

Hypocotyl 3–5 mm. long, ·5–·75 mm. thick, sparsely pubescent.

Cotyledons similar to those of P. reptans, but rotund-oval.

Stem herbaceous, deciduous,

Leaves radical, toothed, lobed or ternate, or digitately five-foliolate.

No. 1. In weak seedlings trifid, in stronger ones five-fid, pale green above, and sparsely hairy, subglabrous below and pale, almost glaucous; lobes obtuse, mucronate; petiole terete, slightly channelled above, sparsely hairy; stipules adnate throughout their length to the petiole, and sheathing the younger leaves.

No. 2. Five- to seven-fid, palmately five-nerved.

No. 3. Seven- to nine-fid, and similarly palmately nerved, more densely clothed with long silky hairs.

Ultimate leaves digitately three- to five-, rarely seven-foliolate, pale green and silky above, felted with white tomentum beneath; leaflets obovate or more often oval, acutely and deeply serrate, basal pair obtained by fission from the middle pair; when seven leaflets are present, the three terminal ones are obtained by fission of the original one into three, and the uppermost pair are attached by their whole width to the primary midrib.

Radical leaves with small scarious stipules adnate to the long petioles for a great part of their length; cauline leaves with gradually shortening petioles, the uppermost almost sessile, and having large, foliaceous, toothed stipules.

Potentilla anserina, *L.* (fig. 316).

Primary root tapering, wiry, with short lateral rootlets, subflexuous.

Hypocotyl short, tapering indistinguishably into the root.

Cotyledons small, oval, obtuse, glabrous, 3·5 mm. long, 2·25 mm. broad; petiole flattened above or slightly grooved, convex beneath, 3 mm. long.

Stem short, herbaceous, throwing off procumbent, stoloniferous flowering branches.

Leaves compound (No. 1 simple), radical, green above and hairy in a young state, more or less densely silky and silvery below and on both surfaces in the adult, very densely beneath; petioles semiterete, channelled above, silky, ultimately densely so; stipules adnate to the petiole for two-thirds of their length, and connate throughout the other third, forming a sheath around the bud or next younger leaf, ultimately splitting and becoming lacerated along their edges on the side of the bud or leaf opposite to the leaf to which they belong, pale brown, scarious, glabrous or thinly hairy.

No. 1. Reniform-triangular, rounded at the base, obscurely five-nerved, three-, five-, to seven-toothed.

No. 2. Subpinnately or digitately trifoliolate.

No. 3. Pinnately five-foliolate; basal pair of leaflets much the smallest, deeply tridentate; terminal leaflet oval, incise-dentate, or serrate.

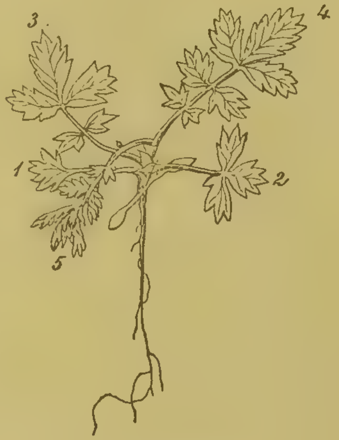

Fig. 316.—*Potentilla anserina.* Half nat. size.

No. 4. Pinnately seven-foliolate; leaflets incise-serrate, decreasing in size from the terminal three to the basal pair, which are small and three- to four-toothed.

No. 5. Interruptedly pinnate; leaflets incise-serrate except the miniature ones; terminal leaflet oval, next pair oblong, next pair minute, lanceolate, aristate, entire; fourth pair from apex oblong, then a minute leaflet, then an ovate pair, and at the base two minute ones.

Ultimate leaves obovate-oblong or oblong, interruptedly imparipinnate, with numerous alternate and opposite leaflets, which attain their maximum size above the middle of the leaf, and are smallest at the base with the exception of the miniature intermediate ones, which are entire or incise-serrate according to their size; terminal three leaflets imperfectly divided at the base and decurrent on the primary midrib, acutely incise-serrate; middle ones and all the larger oblong, rounded at the apex, deeply and acutely incise-serrate.

Potentilla bifurca, *L.* (fig. 317).

Primary root fleshy and stout, suddenly tapering to a long slender point, and throwing off numerous branching adventitious rootlets.

Hypocotyl scarcely developed.

Cotyledons small, ovate-oblong, very obtuse, glabrous, 4·5 mm. long, 3·5 mm. broad; petiole dilated, sheathing at the base, 4·5 mm. long.

Stem herbaceous.

Leaves simple, more or less pinnati-fid or -sect, radical when the plant is young, sparsely hairy on both surfaces, bright green above, paler beneath; petioles subterete, flattened above or subchannelled, hairy, pale green; stipules adnate to the petiole nearly to the top, strongly ciliate at the margin, colourless, with an ovate-acute greenish tip.

No. 1. Rotund, shallowly trifid.

No. 2. Similar, larger, more deeply trifid.

No. 3. Ternately pinnatisect; lateral lobes oval, obtuse; terminal lobe cuneate, trifid.

No. 4. Similar to No. 3, but larger, and the lateral lobes oblique, deeply bifid on the posterior side, with a tooth on the anterior side.

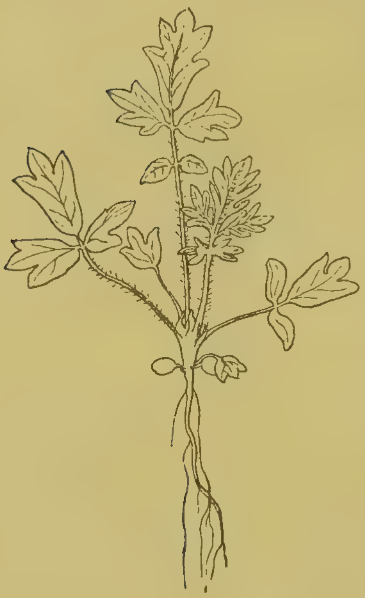

Fig. 317.—*Potentilla bifurca.* Half nat. size.

No. 5. Pinnately five-foliolate; basal pair of lobes small, ovate, entire; middle pair of lobes obliquely trifid; terminal lobe large, cuneate-oblong, pinnatifid.

No. 6. Bipinnatisect with narrowly oblong, obtuse, entire segments.

Alchemilla aphanoides, *Mutis.*

Primary root very long and branching freely.

Hypocotyl terete, glabrous, 4–6 mm. long.

Cotyledons oval, obtuse, entire, glabrous, petiolate; lamina 2·5–

3 mm. long, 2–2·25 mm. wide ; petiole flattened above, connate and sheathing at the base, 1·5–2 mm. long.

Stem herbaceous, erect with the lower internodes scarcely at all developed, thinly and coarsely hairy.

Leaves radical and cauline, alternate, palmately nerved and divided, ciliate, sparsely pilose or almost glabrous, pale glaucous-green above, paler and glaucous beneath ; stipules adnate to the petiole for more than half their length, with the free portion subulate, acute, ciliate, green, sheathing the stem ; petiole channelled above, thinly hairy.

No. 1. Trifid with entire segments.

No. 2. More deeply trifid, with its terminal segment cuneate and trifid, and the lateral ones bifid.

No. 3. Tripartite, with the lateral segments more divided and toothed.

Nos. 4 and 5. Tripartite with cuneate segments ; terminal one trifid and cut with obtuse segments ; lateral ones unequally bifid and variously cut.

Agrimonia viscidula, *Bunge.*

Primary root long, tapering, colourless, giving off strong lateral fibres.

Hypocotyl extremely short, subterranean, colourless, glandular-pubescent.

Cotyledons transversely oblong or suborbicular, rather deeply emarginate, cordate at the base, petiolate, thickened and rather fleshy, glandular-pubescent on both surfaces and on the petiole, green above with an indistinct indication of three nerves, whitish underneath and gibbous with three or four incurved nerves on each side of the midrib ; lamina 5–6·5 mm. long, 6 7·5 mm. wide ; petiole channelled on the upper side, connate at the base, 6–7·25 mm. long.

Stem herbaceous, erect, terete, hairy and glandular-pubescent ; 1st internode undeveloped ; 2nd 1·8 cm. long, or shorter, varying as the seedlings are more or less crowded.

Leaves compound (No. 1 simple) radical and cauline, alternate, penninerved, coarsely hairy and rather densely glandular on both surfaces ; glands sessile ; petiole channelled on the upper surface, semiterete ; stipules in the seedling ovate, obtuse, hairy and glandular.

No. 1. Simple, orbicular, cordate at the base, radiately nerved, shallowly lobed or coarsely toothed with the teeth numerous and tipped with a mucro.

No. 2. Pinnately trifoliolate; terminal leaflet obovate, cuneate, coarsely serrate; lateral leaflets unequally or obliquely ovate.

Acæna ovalifolia, *Ruiz et Pav.* (fig. 318).

Pistil apocarpous, superior, of one carpel which is one-celled, one-ovuled; ovule pendulous from near the apex of the ventral suture, anatropous; radical superior.

Fruit an achene, oblong-fusiform, enclosed in the receptacle which grows up around it, one-seeded, indehiscent, glabrous, dark-coloured; receptacle obovoid or obconical, much narrowed to the base, and again contracted at the orifice enclosing the fruit, tipped with the small persistent calyx-teeth, subtetragonal and produced at its upper end into two to four unequal spine-like appendages tipped with small reversed barbs, glabrous, loosely reticulate, dark brown.

Seed conforming to the interior of the achene, oblong; suddenly tapered to a conical point just above its greatest diameter, which is considerably above its middle, pale straw-coloured, glabrous; testa thin, membranous; micropyle and hilum contiguous, inconspicuous, basal, superior; raphe forming a slender, slightly darker line passing along one side; chalaza apical and inferior, forming a brown spot on the lower end of the seed.

Endosperm absent.

Embryo straight, filling the whole of the interior of the seed, colourless; cotyledons oblong, obtuse, entire, minutely auricled at the base, plano-convex with their edges generally to the two larger spines of the pericarp, but sometimes obliquely to them; radicle turbinate or shortly conical, obtusely pointed, lying in the conical tip of the seed, about a third or a quarter as long as the cotyledons.

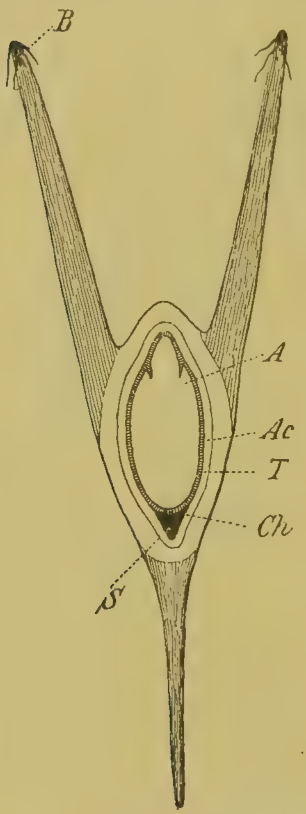

Fig. 318.—*Acæna ovalifolia*, ×10. Longitudinal section of the fruit: *Ac*, achene; *T*, testa; *Ch*, chalaza; *S*, small empty space; *A*, auricle; *B*, barbs or bristle-like appendages.

Acæna myriophylla, *Lindley* (fig. 319).

Primary root simple, tapering.

Hypocotyl mostly subterranean, terete, glabrous, colourless below and green where exposed, 7–9 mm. long.

Cotyledons shortly and broadly oblong, or oblong-orbicular, obtuse, deeply cordate at the base, petiolate, minutely emarginate, radiately seven-nerved from the base, the two upper lateral nerves incurved and uniting with the midrib at the apex, finely reticulate (venation seen by transmitted light only) deep opaque green above, paler beneath, glabrous ; lamina 4–5 mm. long, 3·5–4·5 mm. wide ; petiole semiterete, channelled above, subperfoliate at the base, thinly and minutely hairy, 7–9 mm. long, the margin narrow and colourless with openings into the interior.

Stem herbaceous, procumbent ; primary internodes undeveloped.

Leaves compound, radical and cauline, alternate, stipulate, petiolate, thinly and coarsely hairy, light green above, paler beneath ; petioles semiterete, channelled above, hairy, but sparsely in the seedling, dilated and amplexicaul at the base, proportionately much shorter in the adult plant than in the seedling ; stipules none in the seedling or carried up a considerable way on the petiole and resembling two small, lanceolate, slightly lobed leaflets, adnate for some distance to the petiole in the adult plant with free lanceolate, acute, green and foliaceous tips, more or less cut.

No. 1. Trifoliolate or, from the position of the stipular segments, apparently five-foliolate ; terminal leaflet cuneate, pinnatifid with narrow, subulate or lanceolate, subacute segments ; lateral leaflets opposite or nearly so, subovate, deeply pinnatifid with narrow, subacute or aristate segments.

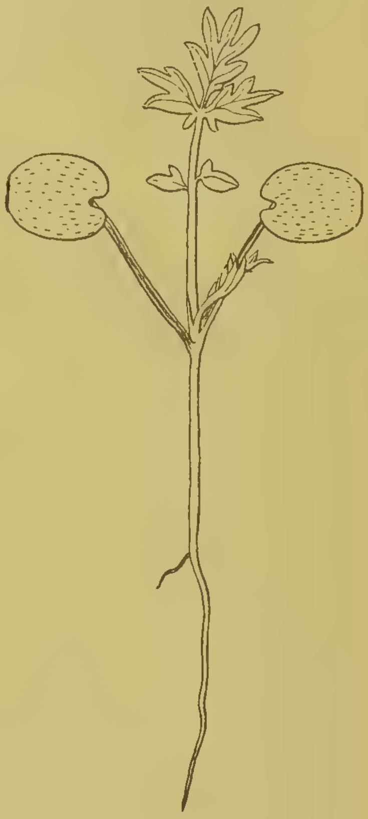

FIG. 319.—*Acæna myriophylla*, × 2.

Ultimate leaf oblanceolate-oblong in outline, pinnate ; leaflets oblong, alternate, pinnatisect with numerous alternate, linear-subulate, acute, aristate segments cut nearly to the midrib.

The seedling of **Acæna millefoliata** is very similar to the last, but the hypocotyl is very short and the cotyledons are oval-oblong.

Poterium Sanguisorba, *L.* (fig. 320).

Pistil apocarpous, superior, enclosed in the hollow receptacle ;

ovary of one, two, or three free carpels, each one-celled, one-ovuled; ovule pendulous, anatropous; radicle superior.

Fruit an achene, enclosed in the ovoid, tetragonal receptacle, ovoid, coriaceous and somewhat fibrous, glabrous, pale brownish, one-celled, one-seeded, indehiscent, closely conforming to the interior of the receptacle both when solitary and when two or three achenes are present.

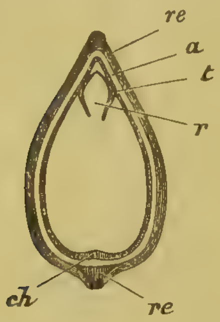

Fig. 320.—*Poterium Sanguisorba.* Longitudinal section of fruit, × 9: *a*, achene; *t*, testa; *r*, radicle; *re*, *re*, hollow receptacle; *ch*, chalaza.

Seed obovoid, suspended from the apex of the achene to the interior of which it closely conforms, pale straw-coloured, except at the chalaza which is pale brown; testa thin, membranous; tegmen thinner, paler, almost white; hilum and micropyle basal, superior; raphe ventral; chalaza apical.

Endosperm absent.

Embryo straight, comparatively large, obovoid, colourless, conforming in shape to the seed; cotyledons rotund-obovate, plano-convex, retuse, minutely emarginate, cordate or shortly auricled at the base, fleshy in the seed; auricles closely adpressed to the radicle, and produced to fill up the space in the seed caused by the cotyledons terminating rather abruptly at the base; radicle turbinate, obtuse, stout, protruded into the narrow conical base of the seed and extending about two-thirds its length beyond the cotyledons.

Seedling (fig. 321).

Primary root slender, tapering, furnished with lateral fibres.

Hypocotyl erect, terete, glabrous, or with a few papillose hairs, colourless or stained red, passing insensibly into the root, about 7 mm. long.

Cotyledons broadly oval, obtuse, minutely emarginate, deeply cordate at the base, faintly striate with numerous nerves arising from the indistinct midrib, glabrous, subfleshy, deep green: lamina 5·25–5·5 mm. long, 4–4·75 mm. wide; petiole subterete, channelled above, hairy, perfoliate at the base, 6·5–7·5 mm. long.

Stem herbaceous, the persistent portion very short; primary internodes undeveloped.

Leaves compound, radical and cauline, alternate, stipulate, petiolate, glabrous or minutely pubescent beneath, deep glaucous-green; petioles semiterete, channelled above, dilated and clasping at the base, hairy in the young stage, glabrous, or nearly so, in the adult; stipules almost wholly adnate to the petiole and membranous with a minute free tip in the seedling, foliaceous in the adult, more or less ciliate at the margin.

No. 1. Pinnately trifoliolate; leaflets petiolulate, rotund, incise-serrate, alternately penninerved and reticulate with the nerves running directly into the subacute serratures—lateral ones subcordate at the base.

No. 2. Trifoliolate; leaflets shortly and broadly oblong, with the lateral ones subcordate at the base.

Ultimate leaves imparipinnate; leaflets numerous, alternate or opposite, varying even on the same leaf, rotund, cordate at the base and overlapping the rachis, and also one another when opposite, subacutely incise-serrate, with minutely mucronate serratures, the terminal one smaller and shorter than the lateral ones, all decreasing in size from the apex of the leaf downwards, and often having small green pinnatifid segments near the base representing the free ends of the stipules.

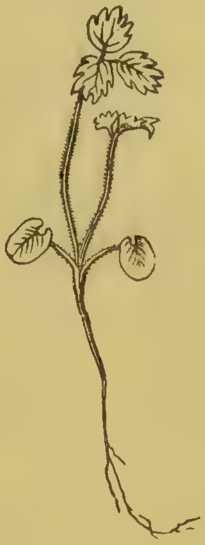
Fig. 321.—*Poterium Sanguisorba.* Nat. size.

Rosa berberidifolia, *Pall.* (fig. 322).

Primary root very long, tapering gradually downwards, with a few very short slender fibrils or none.

Hypocotyl tapering insensibly into the root.

Cotyledons oblong, obtuse, entire, rather thick and fleshy, minutely glandular-ciliate, otherwise glabrous, pale green, shortly petiolate, 1·1 cm. long including the petiole.

Stem suffrutescent, flexuose, glandular-pubescent and prickly; prickles mostly in whorls immediately beneath the insertion of the leaves where the internodes are developed; 1st to 5th internode inclusive undeveloped; 6th 2 mm. long; 7th 1 mm.

Leaves simple (in specimen sketched), cauline, alternate, exstipulate (or stipules reduced to glands), shortly petiolate, glandular-ciliate, otherwise glabrous, equally glaucous on both surfaces; petioles very short, 1–2 mm. long, dilated at the base and amplexicaul.

No. 1. Cuneate, three-toothed at the apex.

No. 2. Cuneate, five-toothed at the apex.

No. 3. Similar.

No. 4. Cuneate-obovate, six-toothed.

No. 5. Narrowly obovate, six-toothed, much narrowed towards the base.

Nos. 6 and 7. Similar to No. 5.

Rosa rugosa, *Thunb. var.* floribunda.

Hypocotyl suffruticose, erect, terete, glandular-pubescent, brownish, 1·4 cm. above the soil.

Cotyledons glandular-ciliate, oval-oblong, obtuse, with a mucro-like intramarginal mark at the apex, 7·5 mm. long, 4·5 mm. broad; petiole glandular-pubescent, channelled above, 3·5 mm. long.

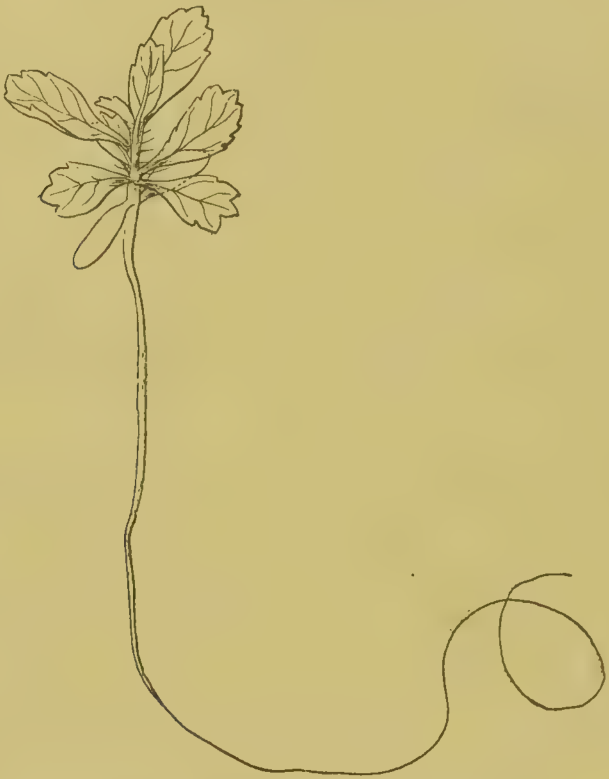

FIG. 322.—*Rosa berberidifolia.* Nat. size.

Stem suffruticose, erect, terete, glandular-pubescent, setose with the setæ mostly arranged in verticils immediately below the insertion of the leaves, pale green, ultimately brownish with white setæ; 1st and 2nd internodes undeveloped; 3rd and 4th each 3 mm. long; 5th 1 mm.; the rest hidden by the sheathing stipules.

Leaves compound, imparipinnate; leaflets serrate, glandular-ciliate, rugose, glabrous above and deep green, paler and subglaucous beneath, glandular-pubescent on the nerves in a young state; petioles channelled above, glandular-pubescent; stipules small and almost wholly adnate to the petioles of the first three leaves; above that they are foliaceous, almost crescent-shaped and free for the upper third of their length, glandular-ciliate, deep green, reticulate, semi-amplexicaul.

No. 1. Very small, unifoliolate; leaflet cuneate, incise-dentate.

No. 2. Trifoliolate; leaflets small obovate-cuneate, serrate mostly above the middle.

No. 3. Similar, but larger and more serrate.

No. 4. Trifoliolate; leaflets oval or subelliptic.

Nos. 5 and 6. Trifoliolate; lateral leaflets broadly oblong; terminal one elliptic.

No. 7. Trifoliolate; lateral leaflets broadly oblong-ovate; terminal one elliptic.

No. 8. Five-foliolate; basal pair of leaflets small, subovate; middle pair unequal—one oblong and the other subelliptic; terminal leaflet elliptic.

Pyrus Aucuparia, *Gaertn.* (fig. 323).

Primary root tapering, slender, very flexuose, with short, rather stout lateral, rootlets, dark-coloured.

Hypocotyl soon becoming woody, erect, terete, glabrous, subflexuose, brown, 8 mm. to 1·5 cm. long.

Cotyledons shortly petiolate, glabrous, deep green; lamina oblong-oval, obtuse, 6 mm. long, 4 mm. wide; petiole grooved above, 1·5 mm. long.

Stem soon becoming woody, erect, terete, hairy, slightly flexuose, pale green, ultimately becoming brown; 1st internode 1·5 mm. long; 2nd 1·5 mm.; 3rd 2 mm.; 4th 2·5 mm.

Leaves compound, ultimately imparipinnate, cauline, alternate, stipulate, petiolate, glabrous except on the petioles, under surface of the midrib and the rachis ultimately glabrescent; petioles subterete, channelled on the upper side; stipules small, ovate, acute, tooth-like.

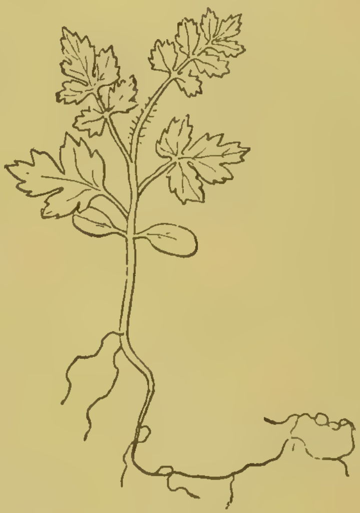

FIG. 323.—*Pyrus Aucuparia.* Nat. size.

No. 1. Triangular-ovate, trifid, lobes serrate.

No. 2. Triangular, tripartite; lateral divisions ovate, acute, serrate; terminal larger, obovate-cuneate, trifid and slightly serrate.

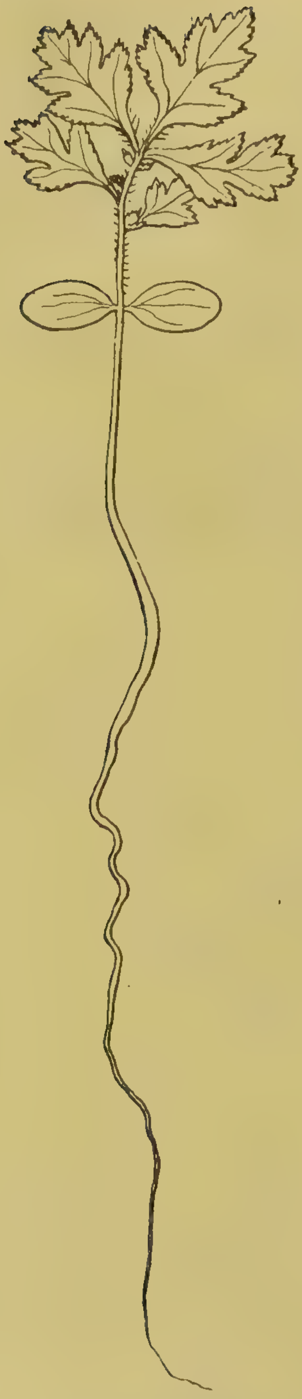

FIG. 324.
Cratægus Oxyacantha (from dry specimen). Nat. size.

No. 3. Pinnately five-foliolate; lateral leaflets ovate, acute, serrate; terminal leaflet cuneate, trifid and serrate.

No. 4. Similar; lateral leaflets acutely serrate; terminal leaflet triangular-ovate, acute, tripartite, acutely serrate.

Ultimate leaves pinnate, of seven to fifteen pairs of leaflets, deep green and glabrous above, whitish and downy on the underside and on the petioles and midrib; leaflets oblong, acute, unequal at the base of the posterior side, acutely and rather evenly serrate, in opposite pairs.

Tubeuf (l.c. p. 71) describes fruit and seeds of Pyrus communis (Pear), P. Malus (Apple), and Cydonia vulgaris (Quince), and also on page 125 the seedlings with figures of the two last. P. Malus has thick, rotund-ovate, almost sessile cotyledons, and doubly serrate, acute primary leaves. Cydonia vulgaris has roundly obovate cotyledons, an obtuse apex, and gradually tapering base. The primary leaves are oval to ovate and very finely serrate.

Cratægus Oxyacantha,[1] *L.* (fig. 324).

Primary root long, slender, tapering, wiry, with slender lateral fibres, flexuose.

Hypocotyl woody, erect, terete, brown, glabrous, 2·5–4·5 cm. long.

Cotyledons subfoliaceous, subcoriaceous, obovate-oblong, obtuse, glabrous, green, changing to brown, rather persistent, narrowed at the base or shortly petiolate, 1–1·2 cm. long, 5–6 mm. wide, obscurely trinerved.

Stem woody, erect, terete or subangled, hairy, brownish; 1st internode 6·5 mm. long; 2nd 3·5 mm.; 3rd 2·5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, hairy on both surfaces, ultimately glabrescent, subcoriaceous, deciduous; stipules foliaceous, variable, lanceolate or semi-ovate, acutely and more or less deeply serrate, with gland-tipped serratures; petioles very short.

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[1] Cf. Tubeuf, l.c. 124, fig. 168.

No. 1. Small, cuneate, trifid and slightly serrate (in some specimens oblanceolate, acute, and simply or slightly doubly serrate).

No. 2. Cuneate, trifid; terminal lobe doubly serrate; lateral lobes simply serrate.

No. 3. Cuneate, trifid, and becoming doubly serrate; terminal lobe again subtrifid.

No. 4. Ovate-oblong, cuneate at the base, lobulate and serrate.

No. 5. Triangular-ovate, trifid or almost tripartite, lobulate and serrate, cuneate at the base.

Ultimate leaves variable in different individuals, cuneate, trifid or pinnatifid and few- or many-lobulate, serrate.

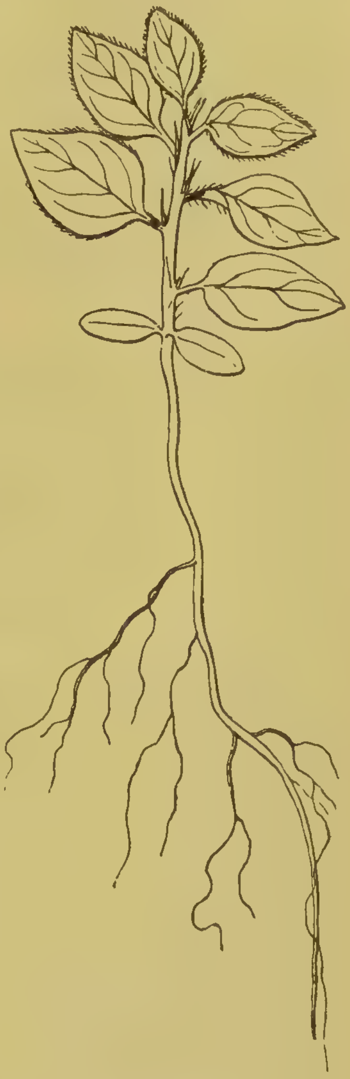

FIG. 325.
Cotoneaster Simonsii.
Nat. size.

Cratægus mexicana, *DC.*

Hypocotyl erect, terete, slender, 3–3·5 cm. above the soil.

Cotyledons oblong-oval, with about two alternate incurved nerves on each side of the midrib, reticulate, thin, horizontal, 1·3–1·5 cm. long, 7–8 mm. wide.

Stem erect, terete, woody; 1st internode 9–10 mm. long; 2nd, 3rd, and 4th very short.

Leaves shortly petiolate, alternately penninerved, nerves ascending, reticulate; petioles very short or almost none in the primary leaves; stipules small in the seedling, subulate, acute.

Nos. 1 and 2. Oblong, acute, rather acutely, simply or doubly serrate.

Nos. 3 and 4. Oblong-elliptic, more or less cuneate at the base, acute, acutely and doubly serrate.

Cotoneaster Simonsii, *Hort.* (fig. 325).

Primary root tapering, wiry, flexuose, with numerous flexuose wiry rootlets, red or brownish.

Hypocotyl woody, erect, terete, glabrous, brownish, 2·4 cm. long.

Cotyledons oval-oblong, obtuse, glabrous, shortly petiolate, 1 cm. long including the petiole, 5 mm. broad.

Stem shrubby, erect, terete, densely hairy, brownish; 1st internode 2·5 mm. long; 2nd 4 mm.; 3rd 3·5 mm.; 4th 3 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, sparingly hairy on both surfaces, densely so on the margins, coriaceous, evergreen, deep green and shining above, paler beneath; petioles channelled above, hairy; stipules subulate, attenuate, free, hairy, brownish, entire.

Nos. 1–6. Ovate, acute, mucronate.

Ultimate leaves ovate, or elliptic-ovate, acute, mucronate.

SAXIFRAGEÆ.

Benth. et Hook. *Gen. Pl.* i. 629.

Fruit and Seed.—The more typical members of this Order have an ovary consisting of two carpels, or occasionally three; but in many, especially the shrubby and arboreal types belonging to the Escallonieæ and Hydrangeæ, the ovary consists of three to five carpels, very rarely more.

In the vast majority of cases the ovary is sunk in the receptacle and syncarpous, with as many cells as there are carpels, rarely one-celled; it is rarely free. We find all intermediate stages between a perfectly inferior, and a perfectly superior ovary in the genus Saxifraga alone. There are only a few species in that genus where the ovary is perfectly apocarpous, and not sunk in the receptacle; but this also happens in Astilbe, Tetracarpæa, Cephalotus follicularis, Pancheria, and Spiræanthemum. The ovules are generally very numerous, and arranged in a double series on the axile, rarely parietal, placentas; frequently they are few, but very rarely solitary and ascending from the base of the cavity of the ovary as in Eremosyne, or pendulous from the top of it as in Whipplea, or geminate and pendulous as in Ixerba.

The fruit is capsular, or baccate, more rarely truly follicular or nut-like. Examples of the last type are met with in Ceratopetalum with a four-winged, bony nut, and in Aphanopetalum and Codia with nuts of a softer or less woody nature, and all one-seeded. The seeds are generally very numerous, and small or minute especially in the herbaceous types, with a membranous or leathery, smooth or pilose testa. Frequently they are more or less evidently winged; and in Brexia madagascariensis the testa is crustaceous. Endosperm is nearly always present in considerable quantity, but in a few it is scanty, or sometimes altogether wanting in Brexia and Ixerba.

The embryo is in the majority of cases very small and ovoid, cylindrical or terete, with plano-convex cotyledons, often scarcely broader than the radicle. Exceptions occur in Brexia and Ixerba, which have a large embryo and flat cotyledons, and in Geissois with flattened seeds, and a large embryo with subfoliaceous cotyledons, equalling the length of the endosperm.

A moderately large embryo is met with in Saxifraga peltata, having linear-oblong cotyledons, which with the radicle are more or less three-fourths as long as the copious endosperm. A similar case is met with in S. crassifolia, which has oblong, longitudinally ribbed seeds from ·75–1·25 mm. in length, and an embryo nearly as long as the endosperm. A very different type is met with in Ribes, the species of which have numerous more or less angled seeds lying in the pulp of a berry. The fruit is one-celled with parietal placentas. The testa is very thick, the outer layer being cartilaginous and hard when dry, but swelling up and mucilaginous in water, while the inner coat is thin and rather crustaceous, or brittle and black. The embryo is ovoid and very minute, lying close to the hilum embedded in a copious endosperm. Ribes glutinosum (fig. 330) represents this type.

Seedlings.—The cotyledons in this Order vary within very narrow limits from ovate to oblong and spathulate. They may also for convenience sake be classified under two heads, namely, large and small. Most if not all of the herbaceous types have very small seeds and small cotyledons. The leading form may be described as ovate, obtuse, entire, shortly petiolate, showing a midrib more or less distinctly, or without any discernible venation in the fresh state. Species agreeing with this type are Saxifraga greenlandica, S. Stracheyi (fig. 327), Rodgersia podophylla (fig. 326), Mitella Breweri, and Escallonia Berteriana (fig. 329). A slight divergence from this is met with in Saxifraga rotundifolia having minute oblong-spathulate cotyledons, and in Heuchera Drummondi with minute, narrowly oblong cotyledons.

Saxifraga greenlandica is one of the mossy-leaved types with cuneate and divided or palmate leaves. The first four are spathulate and entire, followed by two which have each one lateral tooth, and by seven others which are cuneate and trifid. The first leaf of S. Stracheyi is oval and glabrous, while the second is larger and ciliate, and the third obsoletely serrate. The ultimate leaves are obovate, dentate-serrate, and very large. Rodgersia podophylla shows a more striking evolution. The first leaf is cordate with a few distant serratures, the second and third are roundly cordate, shallowly five-lobed and serrate. The ultimate form is peltate, and five-partite with obovate or cuneate, serrated segments, trifid near the apex, sometimes of immense size, and resembling a compound leaf. The first three leaves of Mitella Breweri are suborbicular, tapering to the base, and glandular-ciliate; while the ultimate form is suborbicular, shallowly five-lobed, crenate, deeply cordate at the base with overlapping auricles and a palmate venation. The first two or three leaves of Saxifraga rotundifolia are roundly cuneate and entire, followed by a number of obsoletely trifid ones. The ultimate form is reniform or rotund with an open sinus, dentate and showing numerous veins radiating from the base of the lamina. A very gradual evolution of the leaves is shown by Heuchera Drummondi. Sometimes as many as six of the primary leaves are roundly spathulate, and succeeding ones become larger by degrees, and finally assume a form similar to that of Mitella Breweri. A shrubby type is represented by Escallonia Berteriana having the first five leaves cuneate.

A shrubby type with much larger and more highly developed cotyledons is represented by Ribes saxatile (fig. 331) and R.

glutinosum. The primary or leading ovate form is still preserved, but the cotyledons are rather distinctly five-nerved. Of the former the first two leaves are trifid, while succeeding ones are more or less deeply five-lobed. The cotyledons of R. nigrum are oblong, and the first two leaves are cuneate or lanceolate, often shallowly trifid; the ultimate form is palmately five-lobed and five-nerved.

The variety R. nigrum laciniatum has similar but much smaller cotyledons. A well-marked modification of this type occurs in Philadelphus gracilis (fig. 328) with broadly ovate and emarginate cotyledons. The first two leaves are ovate and entire, whereas the next two are serrulate.

Rodgersia podophylla, *A. Gray* (fig. 326).

Primary root slender, tapering downwards, flexuose, giving off slender lateral rootlets.

Hypocotyl undeveloped or indistinguishable from the root.

Cotyledons ovate, obtuse, entire, shortly petiolate, with a distinct midrib, glabrous, light green; lamina 1·5–2·25 mm. long, 1·25–2 mm. wide; petiole grooved above, convex on the back, dilated at the base and connate, forming a little cup around the plumule, about 1 mm. long.

Stem herbaceous, producing underground a stout, scaly rhizome, and throwing up a stem when about to flower; primary internodes undeveloped.

Leaves simple, trilobed on the stem, five-sect on the rhizome, alternate, stipulate, petiolate, palmatinerved at the base in the seedling, alternately nerved upwards, palmately or peltately nerved in the adult leaves, glabrous or nearly so in the seedling stage; petioles semiterete, channelled above, more or less hairy, short in the seedling, very long on the rhizome of the adult plant, dilated and sheathing at the base; stipules membranous, attached to the petiole, fringed at the apex in the seedling stage.

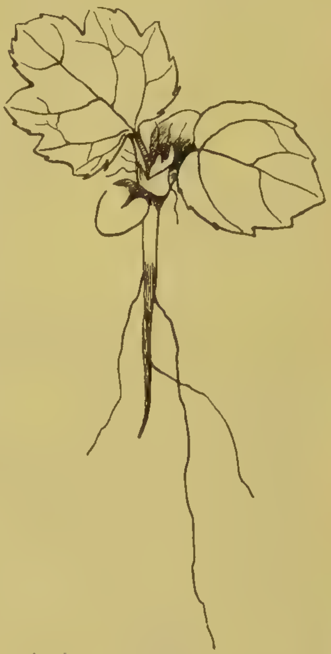

FIG. 326.
Rodgersia podophylla, × 3.

No. 1. Cordate, cuspidate, with two to three small serratures on each side, trinerved at the base with one to two alternate nerves upwards.

No. 2. Rotund-cordate, cuspidate, serrate with glandular mucronate serratures, five-nerved at the base with a few alternate nerves upwards.

No. 3. Similar, rather more deeply cut.

Saxifraga Stracheyi, *Hook. f. et Thoms.* (fig. 327).

Primary root slender, tapering, with slender lateral rootlets.

Hypocotyl terete, pink, 2·25 mm. long.

Cotyledons oblong-ovate, obtuse, shortly petiolate, coriaceous, glabrous, deep green above, paler beneath; lamina 3 mm. long, 1·75 mm. wide; petiole ·75 mm. long.

Stem herbaceous, stout, slowly developed.

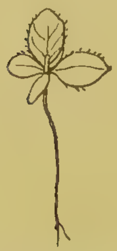

FIG. 327.
Saxifraga Stracheyi.
Nat. size.

Leaves simple, radical and ultimately elevated on the short stem, alternate, stipulate, very shortly petiolate (or the petiole reduced to a sheath margined and topped by the stipules), glabrous, ciliate-serrate, coriaceous, obscurely alternately penninerved, deep green and shining above, pale and punctate beneath; petioles very short and almost reduced to the sheaths; stipules mostly adnate to the sheaths with free fimbriated tips.

No. 1. Ovate-oval, obtuse, entire, not ciliate.

No. 2. Oval, obtuse, entire, distantly ciliate.

No. 3. Oval, obtuse, distinctly ciliate, obsoletely serrate at the apex.

Further stages are developed by many successive gradations in shape and size, till the leaves become obovate, closely ciliate and obtusely serrate along the upper end or half.

Ultimate leaves very large, obovate, tapering to the base, dentate-serrate, ciliate, with mucronate serratures, distinctly alternately penninerved, thick, coriaceous, deep green above with paler nerves, pale green beneath and more or less punctate, sublucid on both surfaces, 37 cm. long, 16 cm. wide including the sheath; serratures largest about the middle of the leaf; petioles almost reduced to the large sheath; stipules adnate to the petiole nearly throughout, then connate by their contiguous margins in front of the leaf forming a hood, entire at the margin, and glabrous or thinly ciliate.

Saxifraga rotundifolia, *L.*

Primary root as in last species.

Hypocotyl subterranean, very short.

Cotyledons minute, oblong-spathulate, obtuse, 2 mm. long, 1 mm. wide.

Stem herbaceous with undeveloped internodes, throwing up annual leafy flowering stems.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, hairy on both surfaces, pale green, paler beneath, often suffused with red; petioles terete, very hairy, dilated and sheathing at the base.

No. 1. Rotund, cuneate at the base, 2 mm. long, 2·25 mm. wide, entire.

Nos. 2 and 3. Rotund, subcuneate at the base, slightly longer than broad, entire.

No. 3. Rotund, subcuneate at the base, with a tooth on one side. Other and numerous intermediate forms are reniform, entire or triangled or trinerved at the base and crenate with three to five rounded, broad teeth.

Ultimate leaves reniform or rotund, deeply cordate at the base, with rounded, more or less overlapping auricles, hairy on both surfaces, crenate-dentate, with broad, shallow, deltoid, obtuse, mucronate crenatures or teeth, and broad, radiating, entire or forked nerves.

Mitella Breweri, *A. Gray.*

Primary root slender, flexuose, giving off flexuose, branching lateral rootlets.

Hypocotyl terete, glabrous, reddish, about 3 mm. long.

Cotyledons minute, ovate or oval, obtuse, subsessile, 2·25 mm. long, 1·5 mm. wide.

Stem herbaceous, very short, with stoloniferous branches.

Leaves simple, radical, alternate, stipulate, petiolate, coarsely hairy and glandular-pubescent, radiately nerved from the base, pale green above, paler beneath; petioles subterete, slightly channelled above, coarsely hairy and pubescent.

Nos. 1–3. Spathulate-rotund, or rotund with a cuneate base, coarsely hairy and glandular-ciliate.

First one 3 mm. long including the petiole, 2 mm. wide. Succeeding forms are small, reniform, entire or tridentate and trinerved; then five- to seven-nerved, and crenate, with obtuse mucronate teeth.

Ultimate leaves rotund, subpalmate, deeply cordate at the base, five- to seven- to nine-nerved, shallowly lobed, and shallowly crenate with mucronulate crenatures, reticulate, pale green, thinly hairy, paler beneath and thinly hairy with prominent nerves; petioles terete, with a slender channel on the upper side, thinly hairy, dilated and clasping at the base; stipules adnate to the petiole, and connate by their edges near the top with two small, free, brownish points.

Heuchera Drummondi, *Hort.*

Primary root as in last species.

Hypocotyl short and indistinguishable from the primary root.

Cotyledons minute, narrowly oblong, obtuse or subacute, 2 mm. long, ·5 mm. wide.

Stem herbaceous, very short, with hairy internodes where developed in the seedling.

Leaves simple, radical, alternate, stipulate, petiolate, radiately nerved from the base, thinly glandular-hairy and glandular-pubescent above, densely glandular-ciliate with unequal-sized hairs, glandular-pubescent beneath, paler and more conspicuously reticulate than on the upper surface; petioles terete, glandular-pubescent, dilated and sheathing at the base; stipules ovate, small, toothed and glandular-hairy, hyaline or reddish.

No. 1. Rotund-spathulate, glandular-ciliate and -hairy, entire, 1·75 mm. long, 1·5 mm. wide.

No. 2, sometimes to No. 6, gradually larger than the first, rotund, spathulate, entire.

Other stages are reniform, entire or minutely tricrenate with mucronulate crenatures; then reniform, obviously tricrenate, tri-nerved; then reniform, five-nerved, five-crenate, and unequally and densely glandular-ciliate.

Larger forms are cordate, obtuse, and crenate with mucronulate crenatures.

Ultimate leaves palmate, deeply cordate at the base, five- to seven- to nine-nerved and -lobed, simply or becoming doubly toothed, with obtuse, mucronate teeth, glandular-pubescent above, glandular-ciliate and paler beneath, coarsely hairy on the nerves and reticulate; stipules adnate to the petiole for more than half their length, with ovate, free, glandular, fringed points.

Philadelphus gracilis, *Hort.* (fig. 328).

Hypocotyl erect, striated, glabrous, 4–8 mm. long, light green or colourless.

Cotyledons small, membranous, ovate, emarginate, shortly petiolate or subsessile, glabrous, green, indistinctly one-nerved.

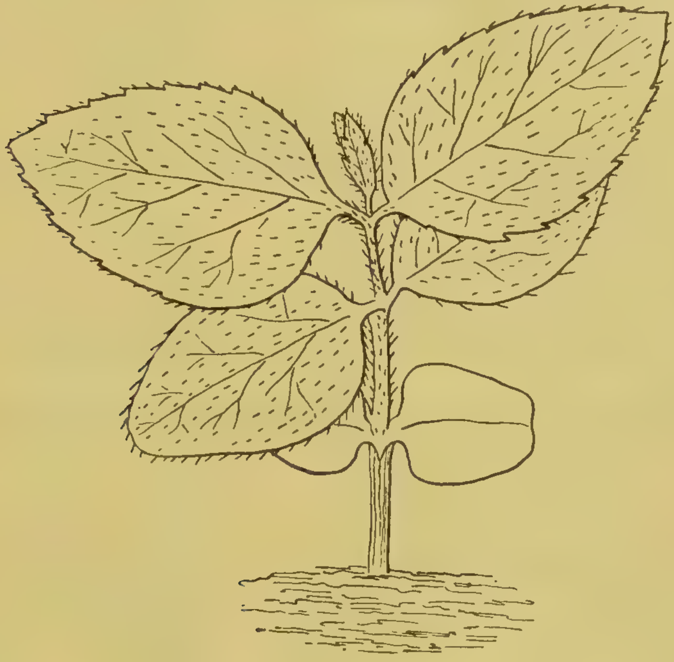

FIG. 328.—*Philadelphus gracilis*, × 2.

Stem erect, terete, herbaceous, hairy; 1st internode 3–6·5 mm. long; 2nd 2–5 mm.

First leaves simple, cauline, opposite, decussate, ovate, subacute, slightly serrate or almost entire in the first pair, petiolate, exstipulate, covered with rather long silky hairs, light green, pinnatinerved.

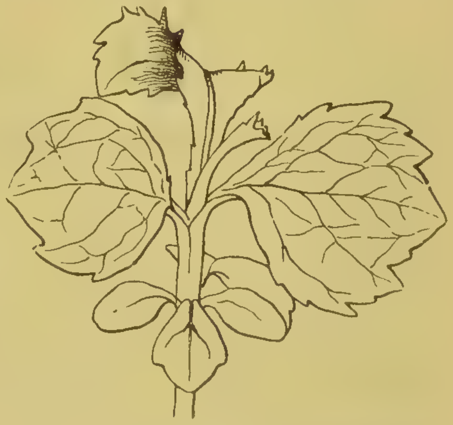

FIG. 329.—*Escallonia Berteriana*, × 4.

Escallonia Berteriana, *DC.* (fig. 329).

Hypocotyl erect, terete, pale green, pubescent with adpressed or incurved hairs, 3–6 mm. long.

Cotyledons ovate, obtuse, glabrous, shortly petiolate; lamina 2·25 mm. long, 1·75 mm. wide; petiole ·5 mm.

Stem erect, terete, ultimately shrubby; 1st internode ·5 mm.; 2nd ·75 mm.; 3rd 1 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, glabrous at least in the seedling state, evergreen; petioles very short, shallowly grooved above.

No. 1. Cuneate, trinerved, obtusely tridentate towards the apex, very small.

No. 2. Larger, cuneate or broadly subelliptic, obtusely three- to five-toothed.

Nos. 3–5. Cuneate-elliptic, obtusely or acutely serrate, gradually larger in each successive leaf, alternately penninerved and reticulate.

Ribes glutinosum, *Jacq.* (fig. 330).

Pistil syncarpous, inferior; ovary of two carpels, one-celled with numerous ovules on two parietal placentas; micropyle basal; ovules anatropous.

Fruit a berry, globose, one-celled, many-seeded, pulpy internally with numerous horizontal seeds embedded in the pulp on two parietal placentas.

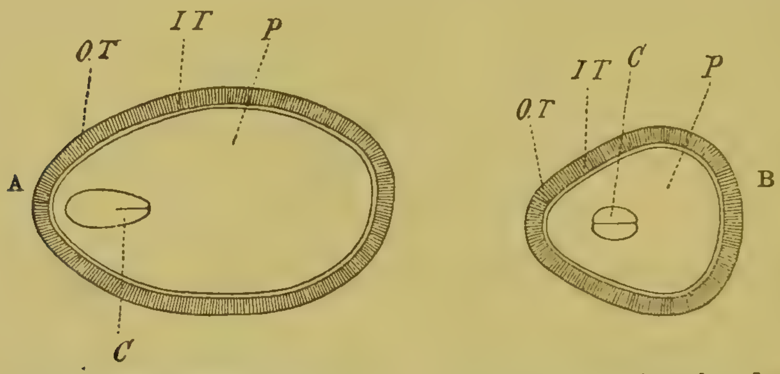

FIG. 330.—*Ribes glutinosum*, × 14. A, longitudinal section of seed; B, transverse section of seed: *OT*, testa; *IT*, tegmen; *P*, endosperm; *C*, cotyledon.

Seed subobovoid, variously angled with obtuse angles, glabrous, deep brown; testa thick, hard when dry, but swelling up and gelatinous when moist; tegmen thin, black, crustaceous; hilum and micropyle basal, contiguous.

Endosperm copious, fleshy, firm, colourless.

Embryo minute at the base of the endosperm, straight, colourless; cotyledons short, oblong, obtuse, entire, plano-convex, sessile; radicle stout, blunt, shorter than the cotyledons.

Ribes saxatile, *Pall.* (fig. 331).

Primary root long, tapering, with a few fibrous lateral rootlets, becoming brown and wiry.

Hypocotyl woody, terete, brownish, sparsely glandular-pubescent, merging into the root.

Cotyledons foliaceous, rather persistent, petiolate, sparsely glandular-pubescent; lamina ovate, obtuse, mucronate, 11 mm. long, 7 mm. wide; petiole slightly channelled above, 7 mm. long.

Stem suffrutescent, erect, terete, sparsely glandular-pubescent; 1st internode 1·5 mm. long; 2nd 6 mm.; 3rd 1·5 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, sparsely glandular-pubescent, pale green; petioles subterete, channelled above, pale green, sparsely glandular-hairy, dilated and amplexicaul at the base.

No. 1. Triangular-ovate, trifid, irregularly serrate.

No. 2. Palmately trinerved and shallowly five-lobed, and serrate.

No. 3. Reniform palmate, trinerved and sub-five-lobed, serrate.

No. 4. Reniform, palmate, five-nerved, five-lobed, serrate.

No. 5. Similar.

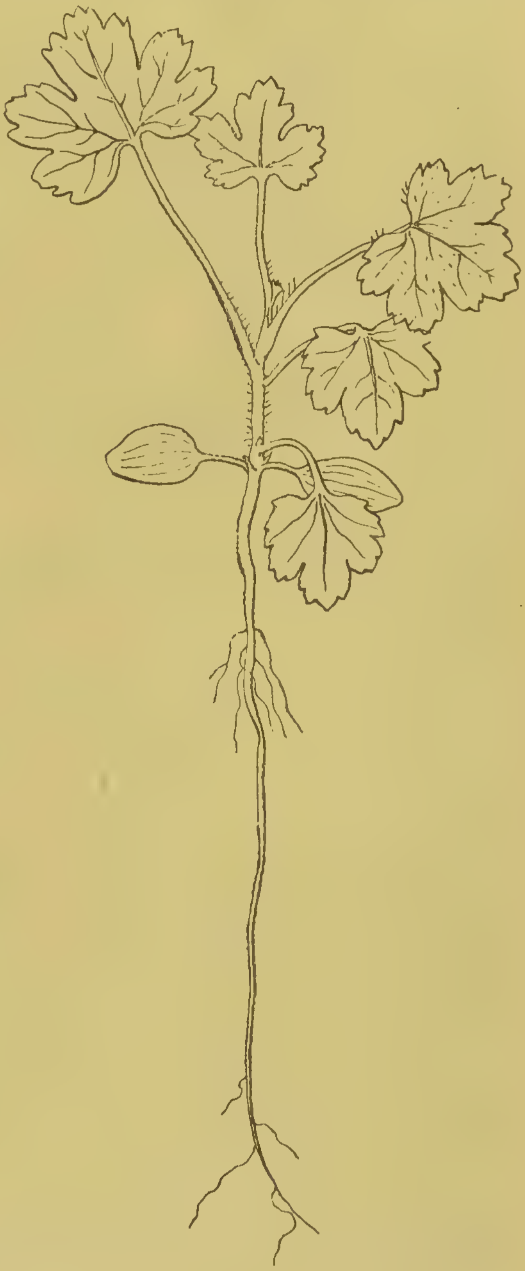

Fig. 381.—*Ribes saxatile.* Nat. size.

Ribes nigrum, *L.*

Hypocotyl erect, terete, glabrous, pale green, soon losing its epidermis and becoming brown and woody.

Cotyledons smaller than in the last species and oblong, obtuse, thinly pubescent at the margin only; lamina 9 mm. long, 5 mm. broad; petiole 4 mm. long.

Stem woody, and similar to that of R. saxatile; 1st internode 1 mm. long; 2nd 1·75 mm.; 3rd 2 mm.; 4th 2 mm.; 5th 7 mm.; 6th 9 mm.; 7th 13 mm.

Leaves very similar to those of R. saxatile, exstipulate (or stipules adnate to the petiole and margined with long, somewhat feathery hairs), thinly glandular-pubescent on both surfaces, and dotted with sessile glands beneath, light green above, paler beneath, highly odoriferous, especially when bruised.

No. 1. Small, ovate, trifid, trinerved.

No. 2. Ovate, trinerved, slightly serrate, with a small lobe on one side.

No. 3. Triangular-ovate, five-nerved, trifid and slightly serrate.

No. 4. Palmately five-nerved and shallowly five-lobed, serrate.

Nos. 5–8. Similar, larger, more definitely lobed and serrate, with glandular-mucronate serratures.

Ribes nigrum, *var.* laciniatum.

Cotyledons smaller and narrower than in the type, and the leaves more deeply divided.

CRASSULACEÆ.

Benth. et Hook. *Gen. Pl.* i. 656.

Fruit and Seed.—The ovary consists of a varying number of carpels from three or five to thirty. The number corresponds to that of the petals, which in Sempervivum sometimes reaches as many as twenty. They are free, or more or less connate or sunk in the receptacle, and one-celled. The ovules are small, numerous, anatropous, and arranged in two or several series upon the ventral suture; more rarely are they few or solitary, as in a few species of Sedum and Tillæa. There are also few ovules in the carpels of Dinacria. When few they may be erect or pendulous. The fruit consists of as many follicles as there are carpels, dehiscing along the ventral suture or, where the carpels are connate, along the dorsal suture. The seeds are minute, oblong, with a membranous or subcoriaceous finely reticulated testa, and contain a fleshy endosperm. The embryo is small and generally shorter than the endosperm, but that of Crassula magnoliæfolia occupies the whole of the seed, and has plano-convex cotyledons. As a rule the latter are very short and obtuse, while the radicle is also short, or sometimes elongated and terete.

The cotyledons in Sedum album are narrowly oblong, and about equal the terete radicle in length.

Seedlings.—The cotyledons observed are all succulent like the plants themselves, and vary in shape from broadly oval or ovate to orbicular. Like the leaves, the cotyledons of Crassula quadrifida are covered with glands secreting a white substance. They persist for a long time, attain considerable size, and generally are very unequal. Cotyledon Silversii is notable for the fleshy rootstock it produces while the cotyledons are still present. The first leaf is suborbicular with a cordate base, and the second is cordate. The cotyledons are rather unsymmetrical. Those of Sedum Rhodiola vary considerably in outline from oval or ovate to obovate, are trinerved and generally slightly emarginate. The first leaf is spathulate and very much smaller than the cotyledons. The two primary leaves of Sedum nicæense are elliptic, succeeded by others that become gradually oblong and then linear, and crowded owing to the non-development of the internodes. Sedum crassipes shows a considerable amount of evolution. The cotyledons are very small, and the first four leaves roundly cordate, almost or quite entire, while the ultimate leaves are linear, distantly toothed and densely arranged on the fleshy stems.

Crassula quadrifida, *Baker* (fig. 332).

Primary root slender, tapering, with slender secondary rootlets and most frequently supplanted by strong adventitious roots from the base of the hypocotyl.

Hypocotyl most frequently very short (in some cases almost none), generally about 1–2 mm. long, succulent, glabrous.

Cotyledons persistent and becoming foliaceous, succulent, glabrous, pitted on both surfaces with gland-like organs secreting a white substance, rotund, obtuse, shortly petiolate, most frequently very unequal in size, green above, purplish beneath; smaller cotyledon including petiole 3·5 mm. long, 6 mm. wide; larger cotyledon including petiole 1·1 cm. long, 8 mm. wide.

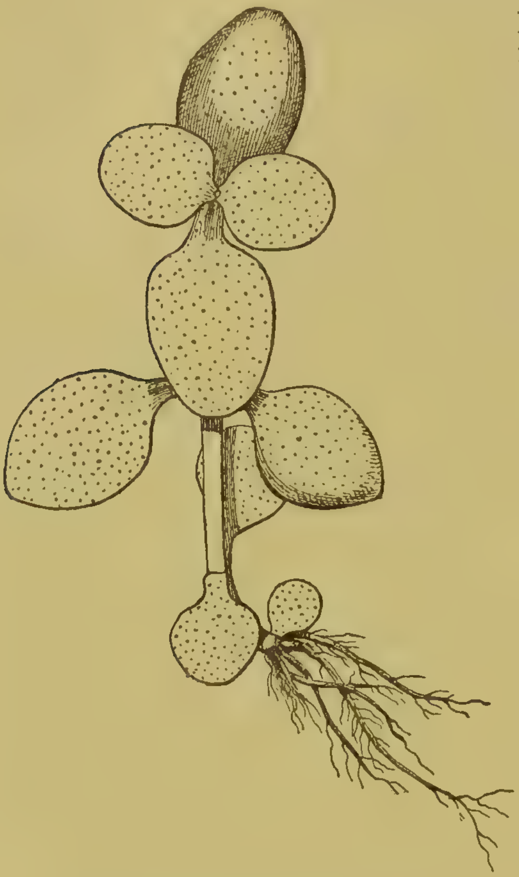

FIG. 332.—*Crassula quadrifida.* Nat. size.

Stem succulent, erect, perennial or shrubby, terete, minutely pubescent; 1st internode 5–8·5 mm. long; 2nd 1·4–1·8 cm.; 3rd about 1·9 cm.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate or subsessile, glabrous, succulent, deep green above, paler beneath, covered on both surfaces with gland-like organs secreting a white substance; petioles flattened above, convex beneath, connate at the base around the stem.

First pair rotund-spathulate or spathulate-elliptic, obtuse.

Second pair oval or rotund-oval, obtuse, cuneate at the base.

Third pair oblong, obtuse.

Fourth pair rotund, obtuse.

These forms vary greatly in individual seedlings.

Ultimate leaves oblong, very obtuse, faintly nerved, or ovate-oblong or rotund, shortly petiolate, covered on both sides with glands secreting a white substance; petioles short, convex beneath, and grooved on the upper side.

Sedum Rhodiola, *DC.* (fig. 333).

Primary root slender, tapering, with a few lateral rootlets, soon equalled, or even superseded, by strong adventitious roots from the base of the hypocotyl.

Hypocotyl short, glabrous, soon becoming ovoid or globose, and forming the primary rootstock of the plant, colourless or purplish, 2–5 mm. long, 2–4 mm. thick.

Cotyledons variable, ovate or rotund-ovate, obovate or elliptic, cuneate at the base, entire or shallowly emarginate, succulent, and continuing to grow for some time, glabrous, subglaucous-green above, paler beneath and glaucous, trinerved, with the lateral nerves curved and enclosing an elliptic space, arising near the base of the lamina and proceeding round the cotyledon parallel with the margin, and again uniting with the midrib close to the apex, best seen on the underside or by transmitted light, petiolate; lamina 4–9 mm. long, 4–8 mm. wide; petiole flattened above, convex on the back, dilated upwards into the lamina, suddenly dilated to a wide base, slightly connate around the plumule, pale green, almost colourless, 6–11 mm. long.

Stem forming a fleshy, thickened rootstock, from which it sends up annual, succulent, flowering stems; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, succulent, glaucous, paler beneath and glaucous, with alternate, ascending nerves, discernible with difficulty; petioles in the seedling grooved above, convex on the back, short, and as the plant grows gradually becoming shorter till the leaves are quite sessile.

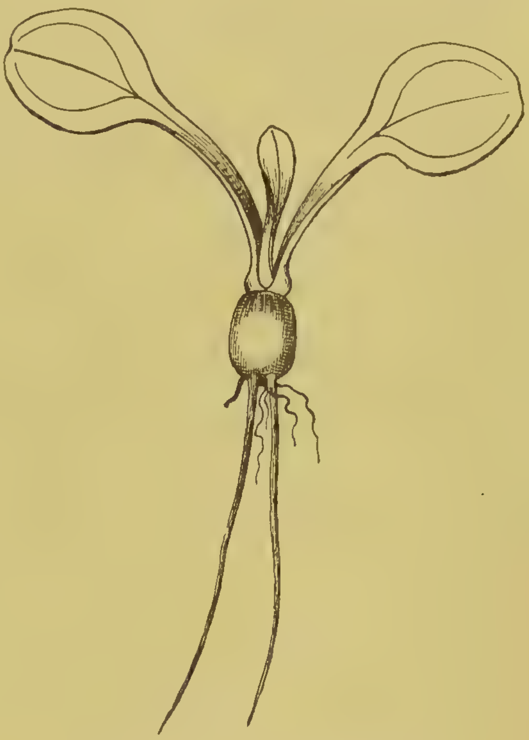

FIG. 333.—*Sedum Rhodiola*, × 2.

No. 1. Much smaller than the cotyledons and both narrower and shorter, spathulate, obtuse, entire, with one to two short, alternate nerves on each side.

Sedum asiaticum, *DC.*

Primary root as in last species.

Hypocotyl stout, succulent, glabrous, purplish, 4 mm. long.

Cotyledons succulent, glaucous, glabrous; lamina broadly oval, obtuse, 3 mm. long, 2·25 mm. wide; petiole flattened on the upper side, 6 mm. long.

Stem herbaceous, succulent; persistent part stout, developing slowly.

Leaves. Arrangement &c. as in last species; petioles succulent, flattened slightly on the upper side, convex beneath.

Nos. 1–4. Rotund-ovate, obtuse, entire, but having marks on the under side foreshadowing teeth.

Ultimate leaves very densely arranged on the flowering stem only, scattered or almost pseudo-verticillate, lanceolate or linear, acute, with a median nerve, distantly serrate, horizontal, light green.

Grammanthes gentianoides, *DC.*

Hypocotyl erect, striated, glabrous, 1·2–2 cm. long, light green or colourless.

Cotyledons subrotund, thick, fleshy, entire, very shortly petiolate, light green, glabrous, without any apparent venation.

Stem erect, terete, herbaceous; 1st internode 5–6 mm. long; 2nd imperceptible at first,

First leaves simple, entire, cauline, opposite, oblong, thick, fleshy, green, glabrous, without any apparent venation.

DROSERACEÆ.

Benth. et Hook. *Gen. Pl.* i. 661.

Fruit and Seed.—The ovary is one- to five-celled, the ovules are usually very numerous, anatropous, axile or parietal, sometimes basal, but very rarely suspended from the apex of the cavity. The raphe and micropyle vary accordingly. The fruit is a capsule with as many cells as the ovary, and dehisces loculicidally. The usually numerous seeds are small and albuminous, with a loose and reticulate or close-fitting testa, which is sometimes covered with granular elevations as in Drosera anglica, or is crustaceous, smooth, and shining. The embryo is straight in the centre of a fleshy endosperm, cylindrical, and about equal to the endosperm in length, with the radicle sometimes projecting beyond the latter. In Drosera anglica, and some other species, as well as in Dionæa muscipula, it is minute, and lies at the base of the endosperm close to the hilum.

Seedlings.—According to Nitschke,[1] Drosera rotundifolia does not start with a rosette of leaves. The young plant works its way up through the Sphagnum, and the first leaves are similar in shape to those of D. anglica. The behaviour of the seedling appears to be dependent upon the medium upon or in which the seed germinates, or, in other words, to the convenience offered the plant to spread out its leaves in a rosette with full exposure to sunlight. It is a case of adaptation to surroundings. Seedlings belonging to other Orders and having large seeds are enabled to carry up their cotyledons or leaves, or both, to the light by the elongation of the hypocotyl or the lower internodes of the stem, while the primary leaves may be reduced to the condition of scales.

The cotyledons of D. rotundifolia are small and spathulate. Those of D. binata are minute and linear-spathulate. The first six or more leaves have an orbicular glandular-hairy lamina, followed by some which are obreniform or broadly triangular. The ultimate leaves are bifurcate with narrowly linear, glandular-hairy segments.

Drosera binata, *Labill.*

Primary root short, stout, blunt, covered with brown root-hairs, with one or two short stout lateral rootlets.

Cotyledons minute, linear-spathulate, glabrous, pale green, about 1–1·5 mm. long.

Stem undeveloped.

Leaves simple, entire at first, then forked, ultimately bifurcate, radical, alternate, stipulate, petiolate, glandular-hairy and grooved above, thickened at the margin, glabrous, grooved beneath, green and shining; glandular hairs with the lower half pale green, the upper half more or less purple and tipped with purple globose glands; petioles compressed with rounded edges, glabrous, grass-green; stipules in the adult plant connate by their contiguous margins in front and at the base of the leaf, fimbriated at the margin, brown, scarious.

Nos. 1–6 or more. Very small with an orbicular glandular-hairy lamina that catches flies even in this small state; the glands secrete a fluid, and the stalks of the hairs incurve on the insect.

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[1] *Bot. Zeit.* 1860, p. 57, taf. ii.

Further stages of the leaves are broadly cuneate, then obtusely triangular; the upper two angles of the leaf gradually elongate until they become acute and slender. The elongated points even at this early stage are involute in vernation, with unusually long hairs very sensitive to contact with an insect. The glands however are quite dry until the points of the leaf are fully expanded.

Ultimate leaves bifurcate, with long petioles, dividing at the apex of the glabrous petiole into two branches which again divide into two branches about 1·1 cm. above the first fork; branches linear, attenuate, glandular-hairy above, grooved on both surfaces, thickened at the margin—two anterior branches shortest, diverging—two posterior ones ascending, and diverging upwards.

Drosophyllum lusitanicum, *Link.*

Primary root long, slender, blackish or brown, with numerous brown root-hairs, but unbranched when young.

Hypocotyl subterranean, colourless, naked, 2 mm. long.

Cotyledons subterranean, and remaining in the seed after germination, petiolate; petioles directed to one side of the stem, colourless, short, but sufficiently long to readily permit of the plumule escaping from the seed.

Stem erect, terete, pale green and glabrous in the early stages; 1st internode 1–1·2 cm. long; 2nd very much shorter.

Leaves simple, entire, cauline, alternate except the first pair, stipulate, sessile, linear, circinate in vernation and rolled backwards, with numerous sessile glands apparently immersed in the tissue of the edges and upper surface, and with stalked and capitate glands on the back and edges but particularly on the latter in the seedling stage.

First pair opposite or on slightly different levels, slightly connate at the base, linear, acute, shallowly grooved above, with a distinct midrib, and stalked glands on the edges, and a few on the back.

Nos. 2 and 3. Alternate, but otherwise very similar, and at this early stage circinate at the tip.

Seedlings with four leaves like the above were densely covered with flies of various sizes both dead and alive, often fixed to the glands by their feet only and struggling to escape. The viscid secretion of the glands may be drawn out to a length of some inches.

HAMAMELIDEÆ.

Benth. et Hook. *Gen. Pl.* i. 664.

Fruit and Seed.—Ovary of two carpels forming a more or less perfectly two-celled fruit, more or less inferior, seldom quite superior.

The ovules are numerous, few or solitary, pendulous, anatropous, and fixed to axile placentas in one or more series, with a superior micropyle and ventral raphe. The woody capsule is bilobed at the apex and dehisces by two bifid valves to the middle or base of the fruit. Sometimes the exocarp separates from the horny endocarp which contains the seeds. Where these are numerous they are imbricated, angled, compressed and winged; but when solitary in each cell they are oblong with a bony or crustaceous testa. A small or moderately thick fleshy layer of endosperm is present embedding the large embryo which is straight with foliaceous cotyledons, and a terete radicle. The latter is equal to, shorter, or longer than the flat cotyledons in different species.

Winged seeds containing the large embryo characteristic of this Order are represented by Rhodoleia Championi (fig. 334). The cotyledons in this case, as in Hamamelis, are subcordate at the base.

Seedlings.—The size and shape of the cotyledons after germination in those cases where the embryo is of proportionately large size while still in the seed, seem to alter less than those with a small embryo embedded in endosperm. An example of this is met with in Bucklandia populnea (fig. 335), which has oblong, entire, subemarginate petiolate cotyledons. They are oblong and flat while still in the seed.

Rhodoleia Championi, *Hook.* (fig. 334).

Pistil syncarpous, inferior; ovary of two carpels, two-celled, many-ovuled; ovules pendulous or horizontal; micropyle superior or horizontal.

Fruit a capsule, cuspidate, glabrous, woody, two-celled, many-seeded, dehiscing by two bifid valves.

Seeds imbricate in two rows, much compressed, variously shaped and angled, sometimes slightly winged, glabrous, pale brown ; testa thicker than the tegmen, subcrustaceous when dry, cortical interiorly ; tegmen thin, membranous, pale brown, closely applied to the endosperm ; hilum and micropyle basal, contiguous.

Endosperm moderately copious, fleshy, colourless when moist.

Embryo large, straight and axile, embedded in the endosperm, and falling a little short of it in length and breadth, colourless ; cotyledons oblong-ovate, very obtuse, rounded at the base, entire, plano-convex, lying in the broader plane of the seed with their backs to the placenta if the seed is pendulous, but with the radicle pointing in that direction if the seed is horizontal, with a distinct midrib and a few alternate ascending lateral nerves ; radicle oblong or cylindrical, obtuse, several times shorter than the cotyledons, imbedded in endosperm close to the micropyle.

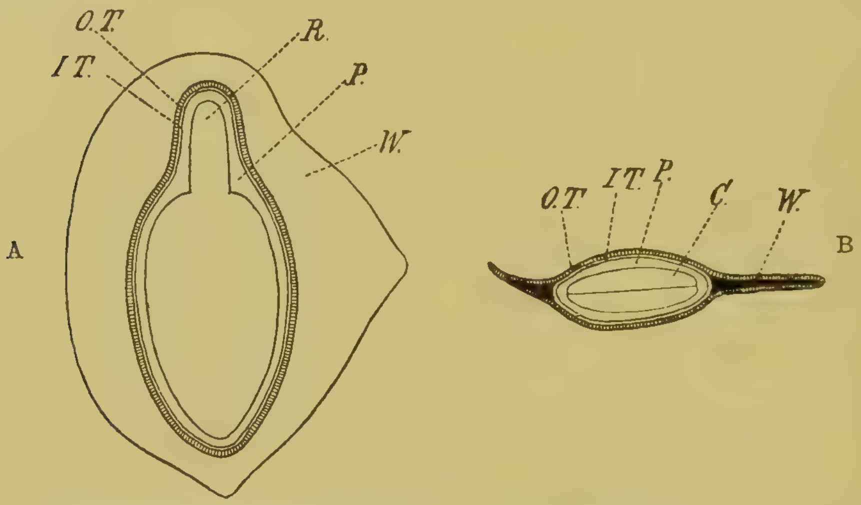

FIG. 334.—*Rhodoleia Championi*, × 7. A, longitudinal section of seed. B, transverse section of same: *OT*, testa; *IT*, tegmen; *C*, cotyledon; *R*, radicle; *P*, endosperm; *W*, wing.

Bucklandia populnea, *R. Br.* (fig. 335).

Hypocotyl woody, erect, terete, pubescent or covered with short, fleshy, hyaline hairs, 8 mm. above the soil.

Cotyledons oblong, obtuse, entire or minutely emarginate, petiolate, coriaceous, glabrous, deep green above, purplish-red beneath ; lamina 1·25 cm. long, 6·5 mm. wide ; petiole flattened above, pubescent like the hypocotyl, 3 mm. long.

Stem woody, erect, terete, purplish, densely covered with brown hairs ; first internode 1·15 cm. long.

Leaves simple, entire, cauline, alternate, stipulate, petiolate, thinly hairy and deep green above, ciliate at the margin, paler beneath and glabrous except on the midrib, coriaceous; petioles subterete, slightly channelled above, purplish and covered with brown hairs; stipules ovate-oblong or oblong, obtuse, pale green or reddish, thinly hairy along the midrib and margin, enclosing and protecting the younger bud or leaf, very large in the adult plant, obliquely oval with three to four nerves on one side of the midrib, and four to five on the other, deciduous.

No. 1. Ovate-subcordate, subacute, trinerved and slightly reticulate.

Ultimate leaves large, cordate, acuminate, five- to seven-nerved, nerves incurved, reticulate, coriaceous, glabrous, cartilaginous at the margin and subundulate, light green, often suffused with crimson; petiole subterete, slightly flattened above, thickened at base and apex, glabrous.

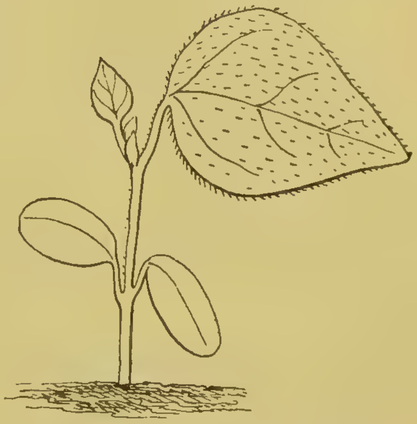

FIG. 335.—*Bucklandia populnea.* Nat. size.

HALORAGEÆ.

Benth. et Hook. *Gen. Pl.* i. 673.

Fruit and Seed.—Ovary of one to four carpels with as many cells, but a three-celled condition is rare. Ovules pendulous, anatropous, and solitary in each carpel. Fruit small and nut-like or baccate, compressed, ribbed, angled, or winged, one- to three-celled, indehiscent, or breaking up into as many cocci as there are carpels. The testa is thin and membranous, enclosing a copious layer of fleshy endosperm. The embryo is somewhat cylindrical, straight, and almost equal to the endosperm in length. The radicle is elongated and stout, the cotyledons proportionately very short and blunt, as in Hippuris vulgaris. In Gunnera scabra and other species the embryo is minute, obcordate, and embedded in endosperm close to the upper end of the seed. In Loudonia the seeds are comparatively very large.

Seedlings.—The cotyledons of Gunnera chilensis (fig. 336) are oblong, trinerved, petiolate, and ciliated. The first leaf is cordate and crenate-serrate.

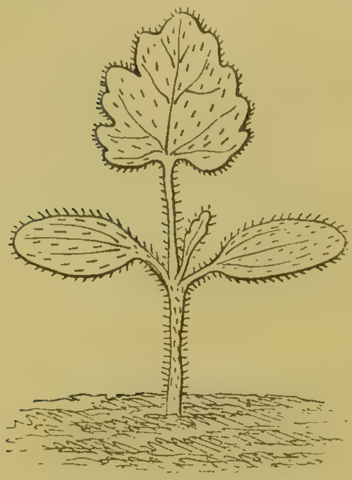

FIG. 336.—*Gunnera chilensis.* Nat. size.

Gunnera chilensis, *Lam.* (fig. 336).

Hypocotyl erect, terete, finely pubescent, greenish, 5–10 mm. long.

Cotyledons oblong-oval, obtuse, entire, petiolate with flat petioles, ciliated, minutely pubescent, light green, indistinctly trinerved.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, petiolate, exstipulate, ovate, obtuse, cordate at the base, obtusely serrate, ciliate, pubescent, light green, palminerved; petioles long, furrowed on the upper side.

COMBRETACEÆ.

Benth. et Hook. *Gen. Pl.* i. 693.

Ovary inferior, one-celled. Ovules two or rarely five, pendulous from the top of the cell, with long funicles, short in the tribe Gyrocarpeæ, anatropous. Fruit drupaceous, often winged longitudinally. Seed usually solitary by arrest; testa membranous, thin; tegmen swollen, intruded between the folds of the cotyledons. Embryo exalbuminous, straight; cotyledons foliaceous, rolled into a spiral, or thick, folded lengthwise, or crumpled. Radicle near the hilum, superior.

Combretum sundaicum, *Miq.*

Hypocotyl undeveloped or very short and subterranean, cotyledons subterranean.

Stem erect, terete, pubescent, soon becoming woody, first internode very short, or more often elongated.

Leaves simple, cauline, alternate, exstipulate with short petioles, nerves alternate and incurved, entire, glabrous, except the pubescent petiole.

No. 1. Sometimes small, subterranean and colourless, or aerial and green, or the first as well as the second is foliaceous, small and ovate.

No. 3. Generally considerably longer and ovate-elliptic, acuminate.

Nos. 4 and 5. In strong seedlings elliptic and generally acuminate, but with an obtuse apex. Much longer than the preceding.

MYRTACEÆ.

Benth. et Hook. *Gen. Pl.* i. 690.

Fruit and Seed.—The syncarpous ovary is entirely sunk in the receptacle, rarely half or wholly superior with the exception of its broad base. The exceptions are Fropiera with a wholly superior ovary, while it is also almost superior in several species of Tristania, Hypocalymna, Bæckea, and Xanthostemon. It is most often two- to many-celled with axile placentas, but sometimes it is one-celled owing to an imperfect dissepiment, with a basal placenta, or the latter is filiform and fixed to the base and apex of the cavity. Very rarely is it one-celled with two parietal placentas. The ovules are campylotropous or anatropous, and vary from two to many, and are arranged in two or more series on each placenta.

The fruit is sometimes capsular, dehiscing vertically by as many valves as there are cells. In other cases it is dry, baccate or drupaceous, one- or many-seeded and indehiscent. The seeds vary greatly in size and form even in the same genus. They have sometimes a membranous (as in the case of Eucalyptus), crustaceous, fleshy, or woody testa. Endosperm is nearly always absent, or when present occupies a small portion of the seed close to the hilum; it is said to be copious in a few cases. The embryo is straight, curved in a circinate manner, or spiral; sometimes it is thick and fleshy with minute cotyledons at the smaller end of the seed, or hooked or almost absent. In other cases the cotyledons are foliaceous, longer than the radicle, sometimes coiled round it; and sometimes they are fleshy, flat, twisted, plaited, or thick and free, or soldered together in a solid mass.

An exceptional case occurs in the genus Feijoa which contains a solitary Brazilian species with angled, albuminous seeds and a straight embryo with flat, foliaceous cotyledons.

The embryos of species of Eucalyptus coming under my notice are remarkable for the way in which the cotyledons are deflexed and become folded or coiled round the radicle. The latter is straight in E. Globulus (fig. 338), as are the petioles for part of their length, while the upper portion is bent at right angles to reach the base of the cotyledons. The whole length of the seed is occupied by the radicle, the straight portion of the petioles, and the real length of the cotyledons which is not great. The size of the latter and their lobed appearance is due to their being deflexed and growing in a lateral direction till they reach the base of the seed while their apical edge becomes coiled round the radicle. The middle portion through which the midrib runs cannot coil round the radicle and is therefore short, thus giving rise to the apical sinus. This will be better understood by reference to the seedlings. A closely similar or identical case occurs in E. marginata, a transverse section of which shows the manner of coiling round the radicle. Although the section showing the coil is transverse to the seed, it is really through the longitudinal plane of the cotyledons. E. stellulata (fig. 341) has very much smaller and narrower seeds, and the coiling is therefore less extensive. The radicle is club-shaped, thickest at the point, and central to the cotyledons.

A very different case is met with in Couroupita guianensis (fig. 347), where the clavate radicle occupies the periphery of the seed, passing entirely round it and girdling the foliaceous, much plaited, or folded and crumpled cotyledons. The seed is large, suborbicular, laterally compressed and oval or elliptic in transverse section.

Seedlings.—The cotyledons in the seedling stage differ greatly according to the size and shape of the seed. Amongst those observed, three types with some remarkable exceptions may be cited ; but there can be little question that if an exhaustive series of species were examined the number both of types and exceptions would be considerably increased. The simplest type is that represented by Callistemon rigidus (fig. 337), having small, elliptic or subrhomboid cotyledons.

This type is also exemplified in C. speciosus, C. Cunninghamii, Psidium, and strikingly so in Tristania conferta (fig. 345). There is a slight departure or modification of the type in Callistemon Cunninghamii where the cotyledons present the appearance of being obscurely trifid. Those of Psidium are much larger than usual, and leaf-like, and those of Melaleuca hypericifolia obovate or roundly ovate.

All of the above species agree in having the first pair of leaves opposite, while a number of them have several pairs with this arrangement. In the seedling stage the species of Callistemon have small, myrtle-like leaves, very different from the adult form which is linear or lanceolate, and rather rigid, with the edges vertical by a twisting of the very short petiole. The primary leaves of Tristania conferta and Psidium are also small and myrtle-like. Those of Melaleuca hypericifolia are small and lanceolate.

Most of the species of Eucalyptus observed have characters in common in the form of the cotyledons. They are transversely oblong, with or without a shallow sinus at the apex, with a short midrib terminating in the sinus, and a longer lateral nerve running along the centre of the lateral lobes. They are practically, therefore, trinerved; but the whole of the venation is sometimes obscure or indiscernible owing to the opacity of the cotyledons. The real apex of the latter is in the notch; and the length of the lateral lobes together with the origin of the sinus is explained below. Species agreeing in the main with the above particulars are Eucalyptus Globulus (fig. 339), E. rostrata, E. cordata, E. leucoxylon (fig. 340) and E. stellulata. A slight modification of the above is seen in E. coccifera having small, obcordate cotyledons with a cuneate base. A greatly exaggerated form is met with in E. occidentalis (fig. 342) where the lateral lobes are ascending or suberect so as to give the cotyledons a furcate appearance strongly resembling those of Pentapetes puniceus amongst the Sterculiaceæ, with similar venation. The cotyledons of E. ficifolia are transversely oblong-reniform, with a moderately deep notch at the base, a very shallow apical sinus, the three nerves copiously branched, and long ascending petioles. On the whole they may be compared to those of a

Geranium. The long petioles show a transition to a still more remarkable type occurring in E. marginata (fig. 343), in which the hypocotyl is subterranean and extremely short, while this deficiency is compensated for by the length of the petioles. The lamina is obcordate, cuneate and trinerved, resembling a Brassica. A striking departure from the common type occurs in E. calophylla (fig. 344) having reniform-orbicular, incipiently emarginate, foliaceous cotyledons of great size. The three nerves are copiously branched, the lateral ones again having three main divisions.

They all agree in having the primary leaves opposite and entire, but these differ slightly in form. Those of E. Globulus are linear-lanceolate; of E. rostrata, E. cordata and E. leucoxylon, lanceolate; of E. stellulata, oval; of E. coccifera, E. marginata, and E. ficifolia, ovate; of E. occidentalis, oblong; and of E. calophylla, cordate, covered on both surfaces with crystalline glands. The primary leaves of many individual specimens of E. ficifolia are more or less distinctly alternate.

Amongst the species with aerial cotyledons are some which must be considered exceptions to the above-mentioned types. Rhodomyrtus tomentosa has oblong-ovate, obtuse, shortly petiolate, penninerved cotyledons which are much longer than the first two pairs of roundly ovate leaves. A most remarkable case occurs in a species of Lecythis, seeds of which were sent to Kew from Trinidad under the name of L. Ollaria (fig. 349). The cotylédons are palmately five-nerved and seven- to nine-lobed with finger-like, bluntly pointed segments. The first five or more leaves are lanceolate, finely serrated and much smaller (especially the first two) than the foliaceous persistent cotyledons.

In a third type the cotyledons where present are subterranean and shortly petiolate as in Eugenia bracteata (fig. 346). The embryo of Lecythis Zabucajo (fig. 348) consists of a solid piece while still in the seed, to the interior of which it strictly conforms. It is narrowly ellipsoid or fusiform, and is evidently homologous with the hypocotyl which has become thickened and fleshy in this remarkable way in order to constitute a storehouse of reserve-material. By remaining in the thick and woody testa both during and after germination it would be protected from the depredations of animals. Cotyledons are absent or very minute. This being the case it follows that the seedling must behave differently from those having cotyledons which are also generally if not always petiolate when they are subterranean or remain in the testa in germination, as in Eugenia bracteata and others mentioned above. The petioles in these cases allow the whole of the embryo to escape from the testa, with exception of the fleshy laminæ of the cotyledons. On the contrary the fleshy hypocotyl of Lecythis Zabucajo is held fast while the plumule splits the testa and pushes its way out at one end of the seed and the radicle at the other. The allied Bertholletia excelsa (fig. 350) behaves in the same way, as well as Barringtonia speciosa.

That there is good ground for considering this fleshy undivided embryo as homologous with the hypocotyl may be inferred from species belonging to other genera. For instance in Couroupita the radicle (so called) is long, clavate and curved round the outside of the cotyledons; in Couratari it is very large and cylindrical; in Planchonia it is very long, clavate and spirally convolute, while the cotyledons are short; but in Careya, Barringtonia, Lecythis and Bertholletia the embryo is quite undivided, with a bud at one end and the radicle proper at the other.

It is usual for some of the primary leaves to be reduced to colourless or brown scales when the cotyledons are subterranean. The first two pairs of Eugenia bracteata are in this condition. A great number of the primary leaves of Bertholletia excelsa are very small and completely cover the lower part of the stem owing to the non-development of the internodes. They gradually change from sheathing organs to perfect leaves, of gradually increasing length. The first eight are colourless, the next five are oblong, followed by one or more lanceolate ones, while the fifteenth and sixteenth are oblong-obovate, but very moderate in size. Only three or four of the first leaves of Lecythis Zabucajo are scale-like. In all three species the colourless leaves would act as a protection to the plumule while pushing its way through the soil, or whatever else might have accumulated above the seeds in a state of nature. The second four leaves of Lecythis are roundly cordate followed by four that are ovate, and then by others which are lanceolate. The ultimate form is oblong-lanceolate, serrate, and the leaves are alternate, distichous, and arranged on the half plan.

Callistemon rigidus, *R. Br.* (fig. 337).

Primary root fibrous, tapering downwards, normal.

Hypocotyl erect, terete, glabrous, reddish, 4–7·5 mm. long.

Cotyledons elliptic or rather rhomboid, obtuse, petiolate, glabrous, with what appear to be alternate, ascending, very obscure nerves in the fresh state, entire, rather thick, light green above, paler beneath, tapering into the petiole; lamina 1·5–3·5 mm. long, 1·25–2·5 mm. wide; petiole flattened above, convex beneath, 1·25–2·5 mm. long.

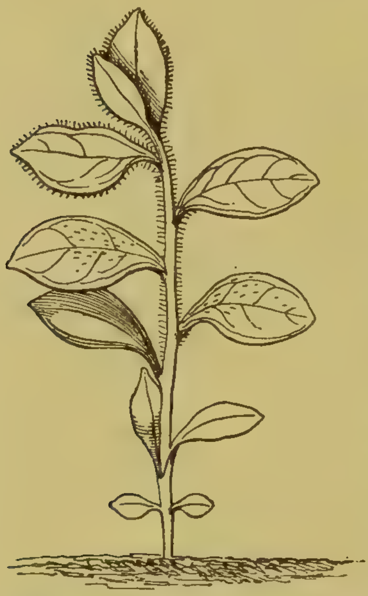

Fig. 337.—*Callistemon rigidus.* Nat. size.

Stem erect, terete, somewhat flexuose, reddish at a very early stage, hairy or subvillous; 1st internode 1·25–2·5 mm. long; 2nd not developed or rarely slightly; 3rd 9–15 mm. long; 4th 4·5–6·5 mm.

Leaves simple, entire, cauline, alternate (first two opposite or almost so), exstipulate, very shortly petiolate in the seedling, but as the plant reaches the adult state the petiole becomes shorter and shorter until the leaves become sessile, merely tapering to the base, trinerved from base to apex, and in the seedling stage showing alternate, ascending nerves that connect the median with the marginal or submarginal ones, pubescent, or silky with adpressed or slightly spreading whitish hairs, dotted with pellucid glands; petioles in the seedling plant short, flattened beneath, convex above.

Nos. 1 and 2. Opposite or nearly so, rhomboid-elliptic, obtuse, obscurely trinerved in the lower half.

Nos. 3 to 12. Elliptic, acute or subacute, more or less distinctly trinerved, light green above, paler beneath and shining.

Ultimate leaves linear, acute, or ending in a spine, trinerved, with the marginal ones sunk in the thickened marginal tissue, suddenly tapered at the apex into the spine, narrowed to the base where by a slight twist the leaf is turned through an angle of 90°, and becomes more or less vertical, that is, with its edges perpendicular to the surface of the earth, silky on both surfaces with adpressed hairs.

Callistemon speciosus, *DC.*

Hypocotyl as in C. rigidus.

Cotyledons rhomboid, obtuse, deep green, and clothed with minute scales; lamina glabrous, 4·5 mm. long, 4 mm. wide; petiole 1·5 mm. long.

Stem woody, erect; early internodes very short or hardly developed.

Leaves simple, entire, cauline, alternate, exstipulate, shortly petiolate, glabrous in the young stage and minutely scaly, deep green, opaque, obscurely alternately penninerved, coriaceous, perforated with translucent glands; petioles very short, flattened above.

Nos. 1 and 2. Opposite, ovate, obtuse.

Ultimate leaves lanceolate, acute, ascending, placed vertically, trinerved, glabrous, coriaceous, pale green, somewhat reticulated; petiole very short, twisted, together with base of leaf, through an angle of 90°.

Callistemon Cunninghamii, ? *F. Muell.*

Primary root as in other species.

Hypocotyl short, erect, terete, glabrous, 3–4 mm. long, light green or colourless.

Cotyledons ovate, obtuse, shallowly trilobed, glabrous, green, one-nerved; petioles rather long, shallowly channelled on the upper face.

Stem erect, terete, herbaceous; 1st internode 1–1·5 mm. long; 2nd, 3rd, 4th, rather longer.

First leaves simple, entire, cauline (first two opposite), others alternate, ovate-oblong, obtuse, entire, petiolate, exstipulate, glabrous, green, trinerved; petioles short, flat, shallowly channelled above.

Melaleuca hypericifolia, *Sm.*

Hypocotyl erect, terete, glabrous, red, 5–10 mm. long.

Cotyledons ovate or rotund, or minutely emarginate, entire, small, petiolate, glabrous, dark green, indistinctly one-nerved.

Stem erect, terete, herbaceous, ultimately woody, glabrous, tinged with red ; 1st internode ·75–1·25 mm. long ; 2nd, 3rd, etc. varying about the same length.

Leaves simple, entire, cauline, opposite, decussate, oblong, obtuse, tapering to the base, sessile, glabrous, light green, one-nerved.

Eucalyptus Globulus, *Labill.* (fig. 338).

Fruit a capsule, three- to four-celled, many-seeded, sunk in the truncated receptacle dehiscing along the middle of the valves.

Seed horizontal, flattened, compressed and angled laterally or dorsally into very various shapes ; testa deep brown or black ; hilum ventral, paler in colour than the rest of the seed.

Endosperm absent.

Embryo straight or nearly so, fleshy, colourless, occupying the whole interior of the seed, and conforming to it in general outline ; cotyledons broader than long, deflexed and convolute over the radicle, which the lobes equal in length ; half of one cotyledon lies over half of the other, and consequently only one half of each cotyledon lies against the testa ; radicle long, stout, fleshy, truncate at the end where it lies against the testa, otherwise wholly enclosed by the longitudinally coiled cotyledons, parallel with the axis and consequently some distance from the hilum.

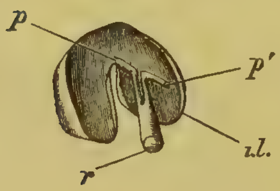

Fig. 338.—*Eucalyptus Globulus.* Cotyledon and radicle, × 8 : *i l*, inner lobe ; *p*, petiole and its attachment ; *p′*, petiole from which the other cotyledon has been separated ; *r*, radicle.

Seedling (fig. 339).

Hypocotyl erect, terete, about 3·5 cm. long.

Cotyledons deeply bifid, trinerved, the middle nerve ending in the sinus ; lobes obovate-oblong, diverging ; lamina 5 mm. long, 9 mm. wide.

Stem woody, erect, terete at the base, and quadrangular upwards, warted on the angles and faces, covered with a glaucous-white bloom, then becoming pale green and ultimately brown ; 1st internode 1·2 cm. long ; 2nd 1·1 cm. ; 3rd 1·45 cm. ; 4th 1 cm. ; 5th 1·35 cm. ; 6th 1·1 cm. ; 7th 1·35 cm. ; 8th 9 mm.

Leaves simple, entire, cauline, opposite, decussate, and sessile in the young plant, alternate and petiolate in the adult, exstipulate, linear-lanceolate, glabrous, perforated with glands, covered with a glaucous bloom, becoming pale green, ultimately dying off brown.

First and second pairs linear-lanceolate, acute, tapering to both ends.

Third and fourth pairs lanceolate-oblong, subacute.

Fifth to eighth pairs (inclusive) oblong, acute.

Lower leaves on branches rotund-oblong, or rounded, then oblong-obtuse, afterwards oblong-acute,—all subcordate at the base.

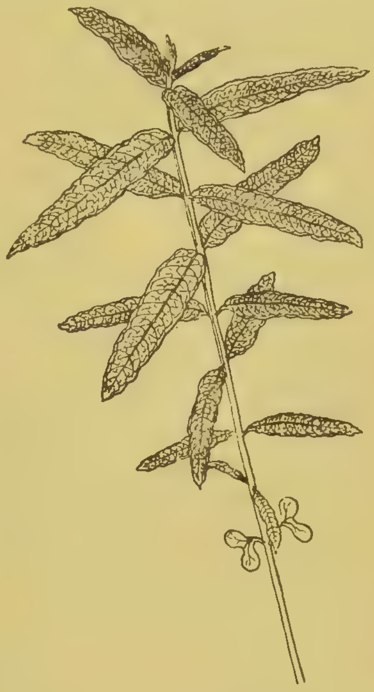

FIG. 339.—*Eucalyptus Globulus.* Half nat. size.

Eucalyptus rostrata, *Schlecht.*

Hypocotyl erect, terete, glabrous, red, 5–8 mm. long.

Cotyledons small, transversely oblong, obtuse, entire, sometimes almost cordate at the base, glabrous, green, indistinctly one-nerved, with short and rather flat petioles.

Stem erect, square, herbaceous, ultimately woody, stained with red; 1st internode 2–4 mm.; 2nd, 3rd and 4th 6–10 mm.

First leaves as in E. Globulus, but oblong-lanceolate, obtuse, light green above, deep red beneath.

Eucalyptus cordata, *Labill.*

Hypocotyl erect, quadrangular, glabrous, red, 3–4·2 cm. long.

Cotyledons very similiar to last species, shallowly emarginate, trinerved.

Stem terete, covered with tubercular or fleshy protuberances, otherwise as in E. rostrata; 1st to 4th internodes 1·5–2·8 cm. long.

First leaves as in E. rostrata, but sometimes entire, or slightly crenate, sessile, or in the case of the first pairs subsessile and acute.

Eucalyptus leucoxylon, *F. Muell.* (fig. 340).

Hypocotyl terete, glabrous, gradually tapering into the radicle, 6–9 mm. long.

Cotyledons as in E. rostrata, but truncate at the end, or sometimes possessing a small apical tooth, 1·25–2 mm. long, 3–4·25 mm. wide; petiole tapered downwards, slightly grooved above, 1·75–2·5 mm. long.

Stem square, glabrous, pale green or reddish, ultimately woody; 1st internode 4·5 mm. long; 2nd 5·5 mm.; 3rd 4·5 mm.

Leaves as in E. Globulus but oblong-lanceolate and petiolate; petioles tapering towards the base, channelled or grooved above.

First pair narrowly oblong, obtuse, small, tapered to the base.

Second and fourth pairs oblong-lanceolate, obtuse, tapering at both ends, but mostly at the base.

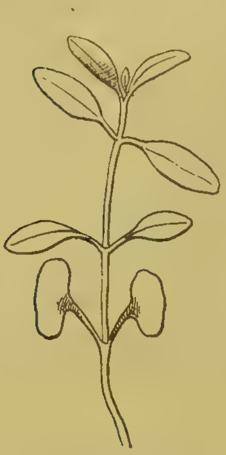

Fig. 340. *Eucalyptus leucoxylon*, × 2.

Eucalyptus stellulata, *Sieb.* (fig. 341).

Fruit a many-seeded capsule, dehiscing loculicidally at the apex.

Seed small, from ·75–1 mm. long, variously angled and shaped, exalbuminous; testa brownish, smooth; hilum inconspicuous.

Embryo straight, filling the interior of the seed, colourless; cotyledons transversely oblong, convolute and folded round the radicle; radicle long, stout, truncate at the apex, occupying the centre of the seed and enveloped by the cotyledons.

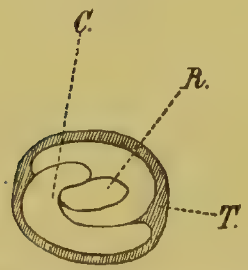

Fig. 341. — *Eucalyptus stellulata*, × 15. Transverse section of seed. *C*, cotyledons; *R*, radicle; *T*, testa.

Eucalyptus coccifera, *Hook. f.*

Hypocotyl terete, woody, glabrous, dark purple near the base, 1·5–2 cm. long, ·5–1 mm. thick.

Cotyledons shortly stalked, ·5–·75 cm. long, ·5 cm. wide, obcordate, cuneate at base, retuse at apex, obscurely nerved, glabrous, not very thick, dark green above, dark purple beneath, rather persistent.

Stem firm, terete, scabrous, dark purple; internodes varying from 1–3 cm. in length, 1 mm. thick.

Leaves as in E. Globulus, but ovate, deep green above, purplish beneath at least in the seedling stage.

Nos. 1 and 2. Including the short scabrous petiole, 1–1·5 cm. long, ·5 cm. wide, ovate-lanceolate, entire, with sunk midrib and obscurely penninerved, glabrous, thin, dark green above, dark purple beneath in the early stages.

Nos. 3 and 4. The same, but more oblong, rounded at both ends.

Nos. 5 and 6. The same, but larger.

Eucalyptus occidentalis, *Endl.* (fig. 342).

Hypocotyl erect, terete, glabrous, 1·5–2·2 cm. long, stained with red.

Cotyledons deeply bifid, petiolate, glabrous, dark green, indistinctly nerved; lobes oblong, narrow, obtuse.

Stem erect, terete, glabrous, herbaceous, ultimately woody; 1st internode 4–5 mm. long.

First leaves linear-oblong, obtuse, petiolate, glabrous, light green, distinctly pinnatinerved.

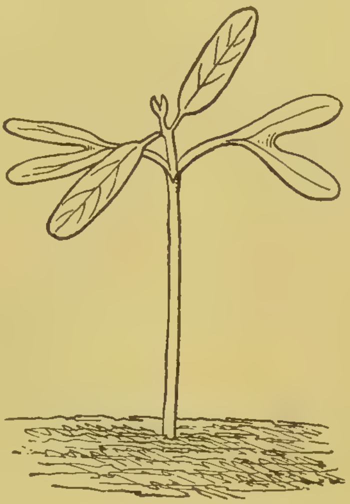

FIG. 342.
Eucalyptus occidentalis, × 2.

Eucalyptus ficifolia, *F. Muell.*

Hypocotyl erect, terete, covered with short bristly hairs 2·5–3 cm. long, reddish.

Cotyledons reniform, obtuse, entire or slightly emarginate, cordate at the base, coriaceous, petiolate, glabrous except on the petioles which are covered with short bristly hairs, dark green, reddish beneath, palminerved.

Stem as in last species, but covered with bristly hairs; 1st internode 2–3·5 cm. long; 2nd 1–2 cm.

First leaves as in E. coccifera, but covered with numerous bristly hairs, tinged with red below, pinnatinerved.

The leaves in many specimens are alternate, not opposite, the internodes between the pairs of leaves at first being very short, but increasing in length after the second pair.

Eucalyptus marginata, *Sm.* (fig. 343).

Hypocotyl short, subterranean.

Cotyledons subrotund or transversely oblong, obtuse, emarginate, asymmetrical, petiolate, coriaceous, glabrous, dark green, reddish beneath, distinctly trinerved; petioles long, plano-convex, stained with red.

Stem as in E. ficifolia.

First leaves sessile, coriaceous, ovate-lanceolate, subacute, glabrous, light green, distinctly pinnatinerved.

Eucalyptus calophylla, *R. Br.* (fig. 344).

Hypocotyl erect, terete, reddish, densely covered with blunt, warty, glandular processes, about 1·3–1·5 cm. above the soil.

Cotyledons large, foliaceous, reniform-orbicular, petiolate, blunt, entire except at the base or incipiently emarginate, glabrous, deep opaque green and punctate above, much paler beneath and more conspicuously punctate, strongly trinerved from the base with the lateral nerves trifurcate a little above the base, and ascending while the midrib proceeds nearly straight to the apex with a few alternate, ascending branches; lamina 2·3 cm. long, 3 cm. wide; petiole subterete, flattened on the upper side above the base and shallowly grooved upwards, much thickened and perfoliate at the base, densely covered with small glandular processes, about 1·6 cm. long.

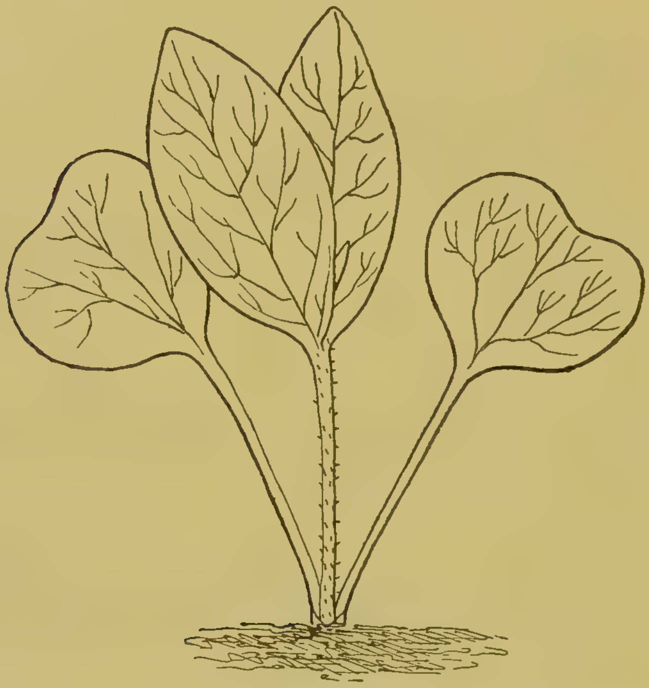

FIG. 343.—*Eucalyptus marginata.* Nat. size.

Stem erect, terete, ultimately woody, green in the young state, densely covered with irregular crystalline, glandular processes; 1st internode 2·25 cm. long; 2nd 5–6 mm.

Leaves opposite in the young plant, covered on both surfaces and at the margin, but especially on the petioles and midrib beneath, with various sized crystalline, glandular processes, rather closely and ascendingly penninerved and reticulate; petioles dilated and slightly flattened on the upper side at the base, otherwise nearly terete and tapering upwards.

First pair broadly cordate, obtuse, tipped with a glandular mucro.

Second pair cordate-ovate, obtuse, tipped with a glandular mucro, alternate.

Tristania conferta, *R. Br.* (fig. 345).

Primary root tapering downwards, sending off numerous lateral fibres.

Hypocotyl erect, quadrangular, glabrous, red, 1–1·3 cm. long.

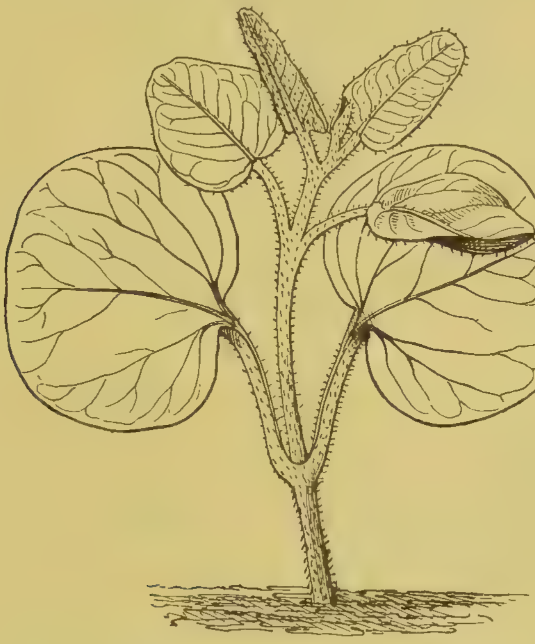

Fig. 344.—*Eucalyptus calophylla.* Nat. size

Cotyledons small, rhomboid, ovate, obtuse, entire somewhat fleshy, green, glabrous, petiolate, trinerved ; petiole rather long and flat, glabrous.

Stem erect, quadrangular, slightly hairy, green ; 1st internode 1·2–1·5 cm. long ; 2nd internode 3–4 mm.

First leaves entire, opposite, decussate, lanceolate, oval, obtuse, slightly ciliate, minutely hairy, green, pinnatinerved ; petioles short, slightly furrowed above.

Psidium sp.

Hypocotyl erect, terete or obtusely quadrangular, glabrous, pale green, about 1·8 cm. above the soil.

Cotyledons aerial, ovate, acute, cuneate at the base, glabrous, shortly petiolate, coriaceous, thin, light green on both surfaces; lamina 1·3 cm. long, 8 mm. wide; petiole about 1 mm. long.

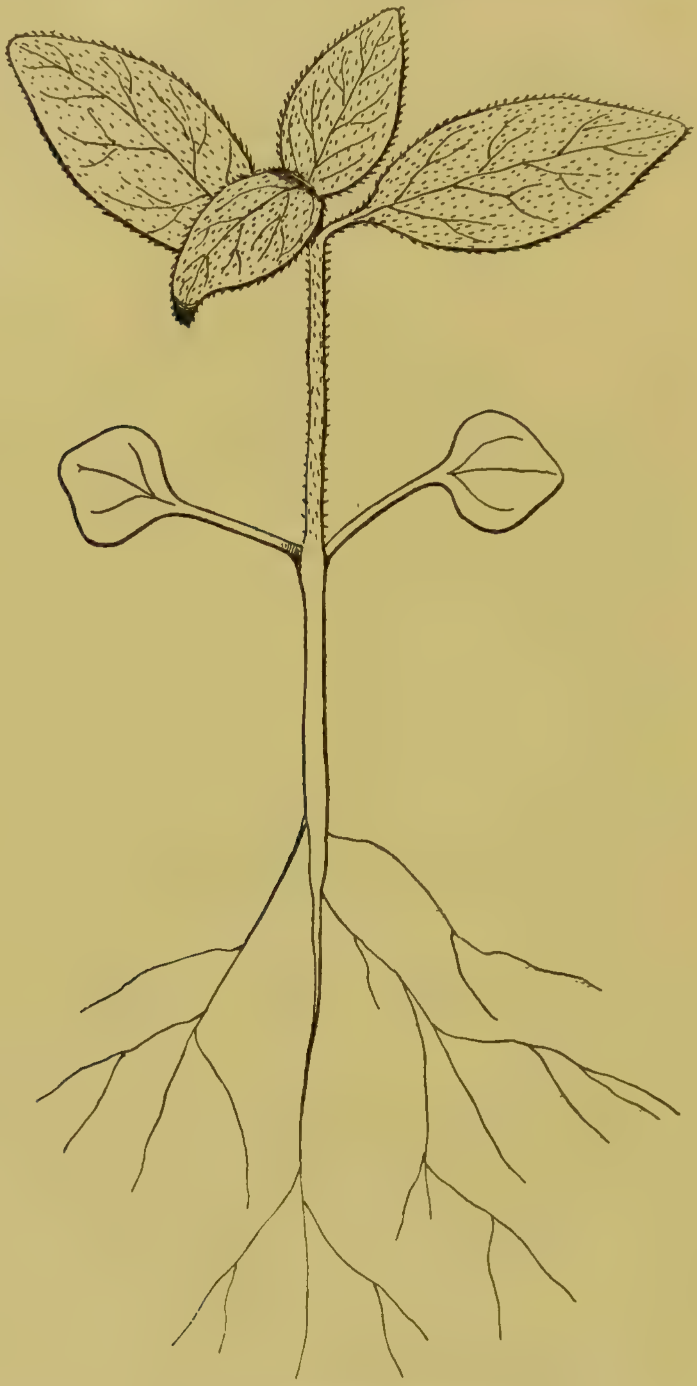

FIG. 345.—*Tristania conferta*, × 2.

Stem woody, erect, acutely quadrangular or almost four-winged, glabrous, pale reddish; 1st internode 1·4 cm. long; 2nd 1·9 cm.; 3rd 7·5 mm.

Leaves entire, opposite, glabrous, deep green above, paler beneath, shining on both surfaces; petioles very short, glabrous, channelled above.

First to third pairs small, elliptic, obtuse, minutely cuspidate, or apiculate.

Rhodomyrtus tomentosa, *Wight.*

Hypocotyl erect, terete, glabrous, 5–10 mm. long, light green.

Cotyledons linear-oblong, obtuse, entire, shortly petiolate, glabrous, shiny green, pinnatinerved like the leaves.

Stem erect, somewhat quadrangular, herbaceous, ultimately woody; 1st internode 3–4 mm. long; 2nd shorter.

First leaves simple, entire, cauline, opposite, ovate, obtuse, glabrous, shiny green, coriaceous with pellucid glands, exstipulate, pinnatinerved; petioles short, shallowly furrowed above.

Eugenia bracteata, *Räusch* (fig. 346).

Hypocotyl subterranean.

Cotyledons subterrannean and remaining in the seed.

Stem woody, erect, terete, densely pubescent, pale green, ultimately brown; 1st internode 1 cm. long; 2nd 1·15 cm.; 3rd 1·5 cm.; 4th 8 mm.

Leaves as in last species, obscurely penninerved, deep green above, pale below, shining on both surfaces, perforated with glands; petioles very short, channelled above, pubescent.

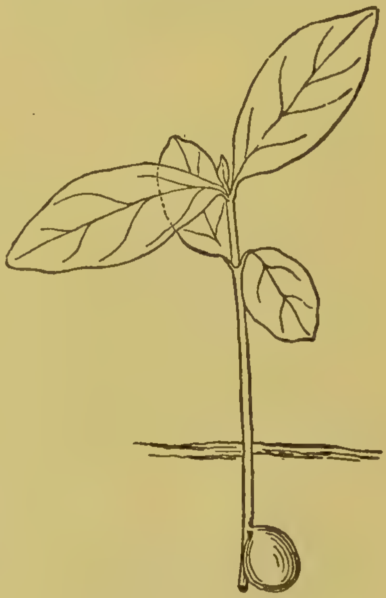

Fig. 346.—*Eugenia bracteata.* Four-fifths nat. size.

First and second pairs reduced to small scales, green, ultimately brown.

Third pair oval, obtuse, foliaceous.

Fourth pair elliptic, obtuse, much larger.

Couroupita guianensis, *Aubl.* (fig. 347).

Pistil syncarpous, superior; ovary of five to seven carpels, many-ovuled; ovules campylotropous.

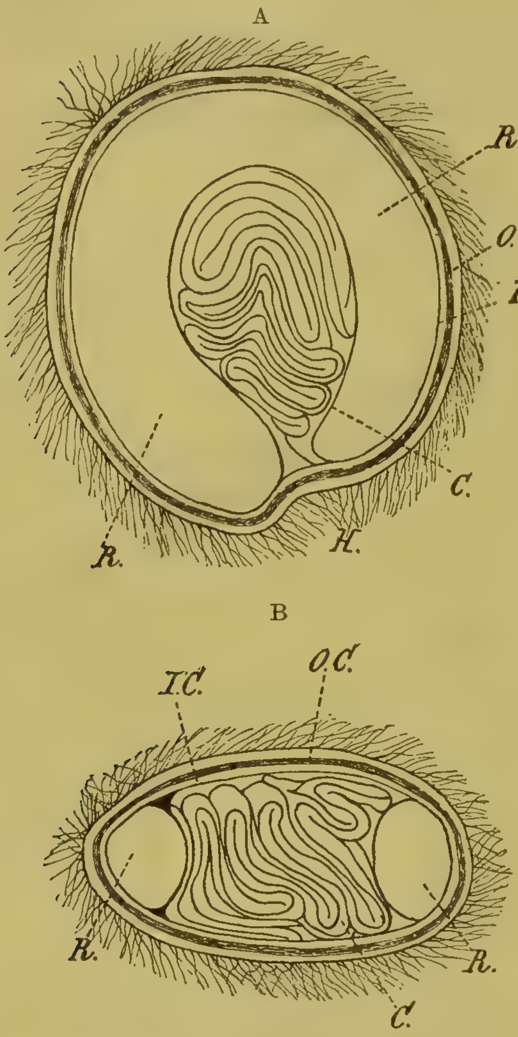

Fig. 347.—*Couroupita guianensis,* × 4. A, longitudinal section of seed. B, transverse section of seed. *H*, hilum; *R*, radicle; *C*, cotyledons; *O C*, testa; *I C*, tegmen.

Fruit subglobose, coriaceous or almost woody, many-seeded, indehiscent.

Seed large, villous, transversely oblong, considerably flattened; testa crustaceous by a thickening and hardening of the inner layer of the outer coat, villous; hilum rather conspicuous.

Endosperm absent.

Embryo curved or rounded on itself, or involute, rather compressed, filling the whole of the seed, and pinkish-white; cotyledons large, oblong, contorted and plicate with numerous intricate folds; radicle very long, curved all round the seed and enclosing the cotyledons in the centre, clavate, obtuse.

Lecythis Zabucajo, *Aubl.* (fig. 348).

Primary root very long, stout, woody, giving off a few lateral fibres, and leaving the seed at the opposite end to the plumule.

Hypocotyl remaining in the seed, subterranean, large, fleshy, colourless, forming an oblong mass conforming to the shape of the cavity of the seed, and tapering to each end.

Cotyledons probably absent.

Stem erect, terete, soon becoming woody, tapering gradually upwards, glabrous, light green.

Leaves always simple, alternate, cauline, exstipulate, sessile in the seedling, but ultimately shortly stalked, distichous, serrated, glabrous, light green, penninerved and reticulated.

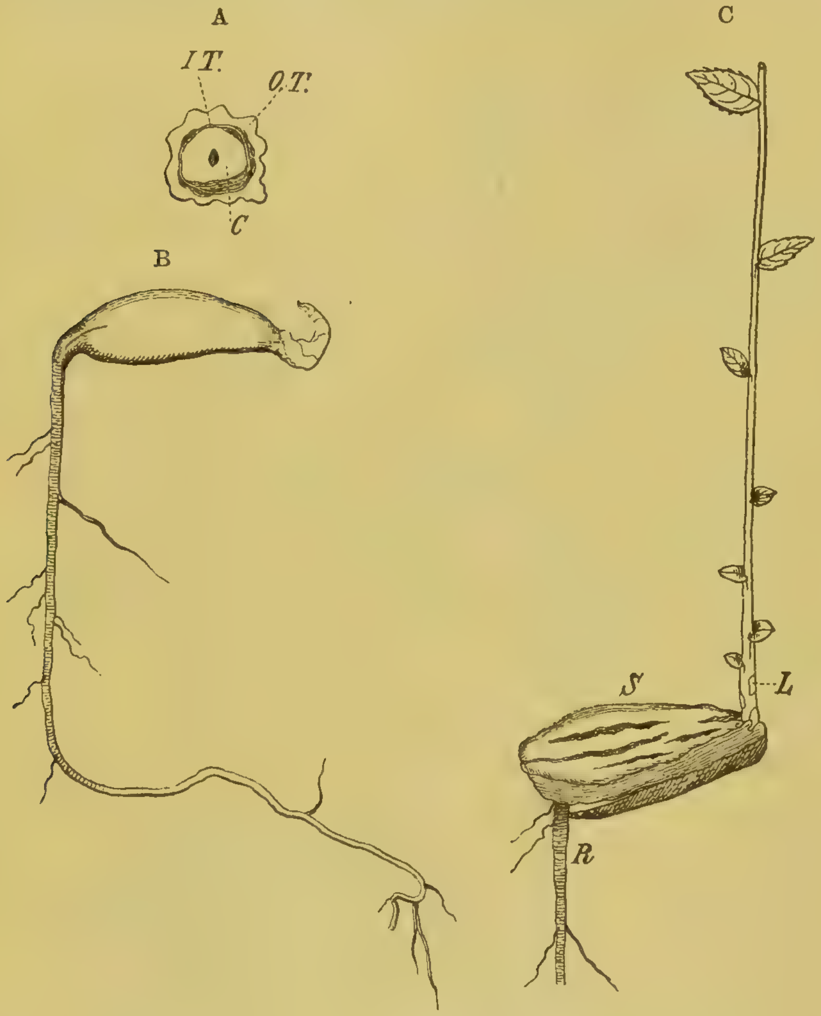

Fig. 348.—*Lecythis Zabucajo.* A, transverse section of seed: *OT*, testa; *IT*, tegmen; *C*, fleshy hypocotyl. B, germinating embryo removed from seed. C, seedling: *S*, seed; *R*, radicle; *L*, scale-like leaf. Half nat. size.

Nos. 1–3 or 4. Small, scale-like, clasping the stem at its base.

Nos. 4–7. Broadly cordate, obtuse, clasping and decurrent on the stem, forming a slender line for some distance, or, on the upper portion of the seedling, running down as far as the next internode.

Nos. 8–11. Ovate, acute or acuminate, slightly toothed; No. 11 slightly stalked.

Nos. 12–14. Lanceolate, acuminate, distantly serrulate, shortly petiolate.

Lecythis Ollaria, *L.* ? (fig. 349).

The seedling figured below (fig. 349) was grown under the above name, but I do not feel clear about it. Possibly it is a species of Couratari. I figure it, however, on account of the remarkable cotyledons, which resemble those of Tilia.

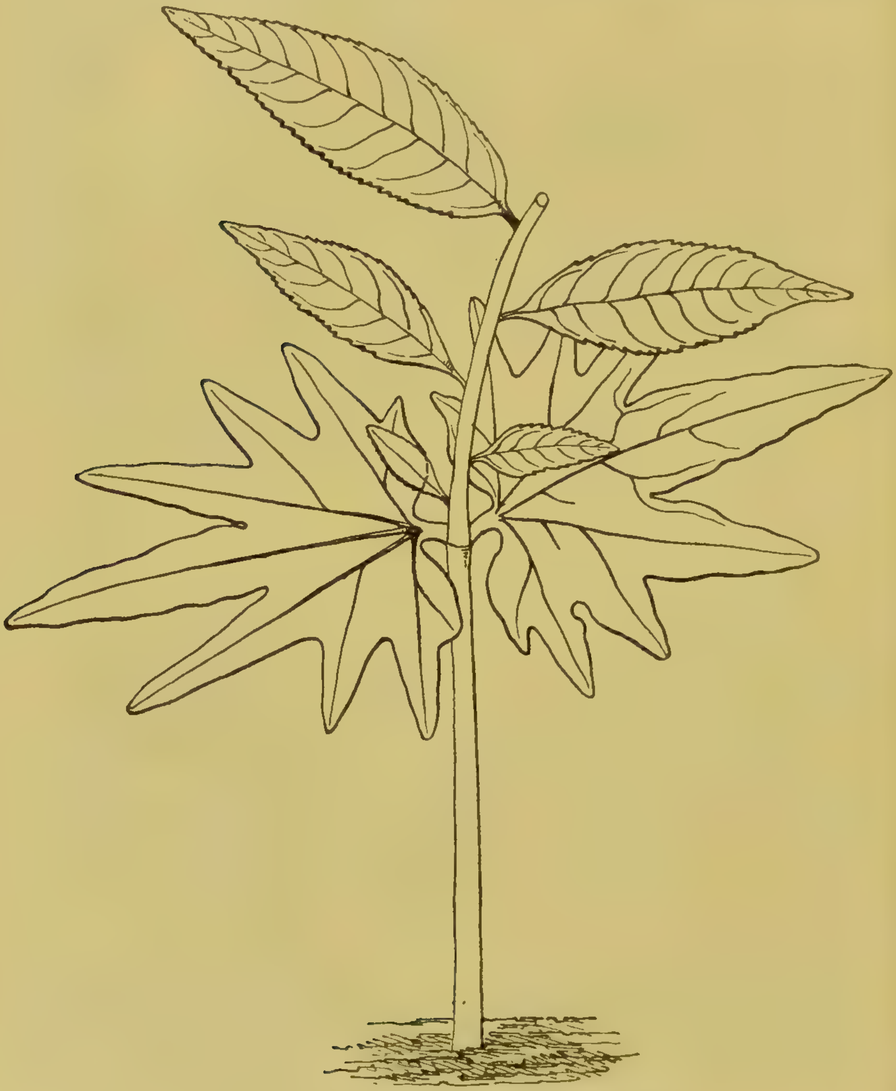

Fig. 349.—*Lecythis Ollaria.* Nat size.

Hypocotyl erect, terete, finely pubescent, 5–9 cm. or more above the soil.

Cotyledons very large, foliaceous, aerial, palmately seven- to eleven-nerved and -lobed, reticulated, glabrous, membranous, shining, shortly petiolate, 5–6 cm. long including the petiole, 4·5–5·2 cm. wide; middle segment lanceolate, obtuse, by far the longest, the others gradually becoming shorter towards the base; petiole 2·5–3 mm. long.

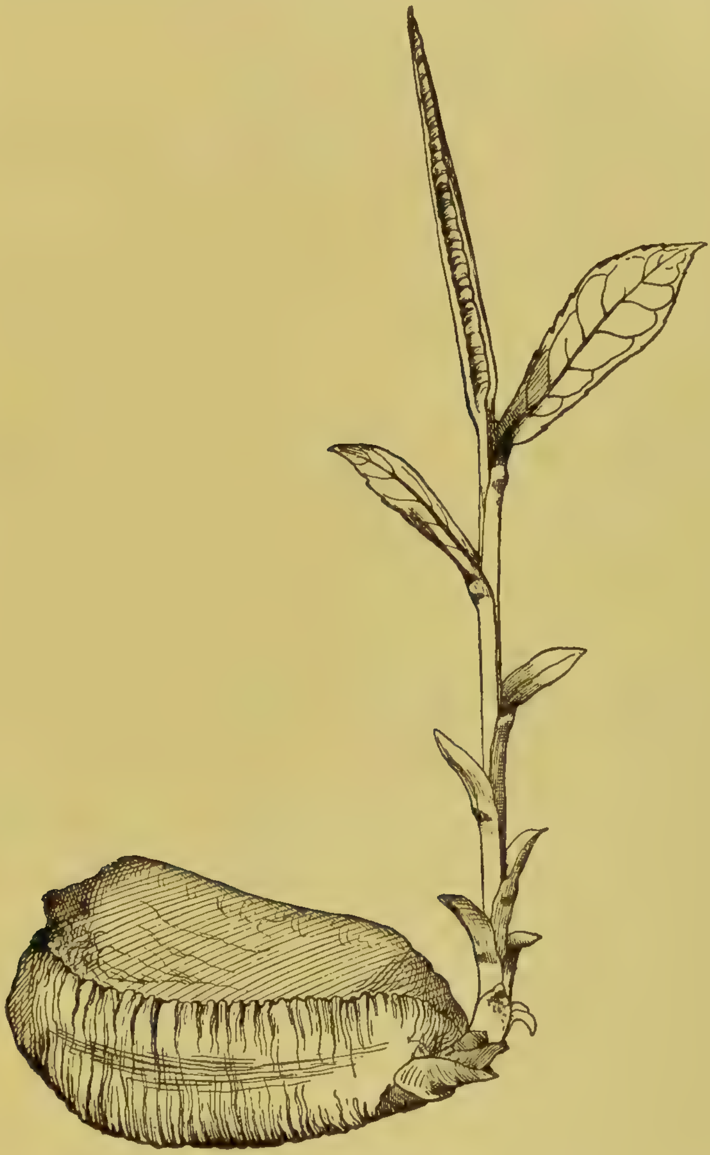

Fig. 350.—*Bertholletia excelsa.* Nat. size.

Stem erect or arching, terete, pubescent, more or less flexuose, ultimately woody; 1st internode 4 mm. long; 2nd 7 mm.; the others gradually becoming a little longer.

Leaves simple, cauline, alternate, exstipulate, shortly petiolate, serrate, alternately incurvinerved, glabrous, bronze-coloured in a young state, ultimately bright green and shining, distichous and arranged on the half plan.

No. 1. Very small, lanceolate, obtuse, 7–9 mm. long including the petiole.

No. 2. Lanceolate, three times as large as No. 1.

Nos. 3–8. Lanceolate, acuminate, obtuse, and gradually larger.

Bertholletia excelsa, *H. B. K.* (fig. 350).

Radicle emerging towards the opposite end of the seed to that whence the plumule emerges.

Hypocotyl, as in Lecythis, very thick and fleshy, conforming to and filling the interior of the seed, subterranean.

Cotyledons absent.

Stem erect, terete, glabrous, stout, colourless beneath the soil and deep brown above it, ultimately woody; first eight to ten internodes very short and covered by scale-like leaves, mostly beneath the soil; 11–15th gradually elongating from 6–14 mm. long.

Leaves simple, cauline, alternate, or the lower ones appearing opposite owing to the suppression or shortening of the internodes, exstipulate, petiolate, or the lower sessile and clasping the stem and scale-like, alternately incurvinerved and reticulate, glabrous, shining on both surfaces, at least when young, and in that condition more or less stained with brownish-red; petioles wanting in a great number of the primary leaves, or short and sheath-like.

Nos. 1–8 (in specimen examined). Small, colourless, subterranean, scale-like.

Nos. 9–13. Green, oblong, acute, aerial, carinate owing to the stout midrib, entire, ascending or spreading.

No. 14. Lanceolate-oblong, subacuminate, entire or slightly serrulate, much larger than the previous ones.

Nos. 15 and 16. Oblong-obovate, acuminate, serrulate, narrowed at the base into a short sheath-like petiole, clasping the stem on one side.

MELASTOMACEÆ.

Benth. et Hook. *Gen. Pl.* i. 725.

Fruit and Seed.—The ovary is free or more or less adnate to the receptacular cup; when it matures into the fruit the free portion, if any, is nearly always enclosed in the cup. It varies with two to many carpels cohering to form as many cells. The members of the suborder Memecyleæ constitute an exception, inasmuch as the septa often disappear making the ovary one-celled, with the ovules arranged verticillately on a free central columella. In the suborder Melastomeæ the ovules are very numerous and inserted on placentas that project far into the interior of the ovary; while in the suborder Astronieæ the numerous ovules are ascending and inserted on prominent basal or parietal placentas. In all cases they are anatropous. They are very few and definite in the tribe Miconieæ of the Melastomeæ and in the suborder Memecyleæ.

The fruit is baccate or capsular, dehiscing by valves or bursting irregularly. The seeds are varied in outline from cuneate, cochleate, or pyramidal to filiform and are very small, except in the cases mentioned where the ovules are few when they are large, globose or hemispherical. The testa is membranous, leathery, crustaceous and smooth or rugose, in Huberia and Acanthella it is winged. The raphe is sometimes enlarged and spongy. The seed is exalbuminous, and whether large or small the embryo occupies the whole of the interior, to which it conforms. In the suborder Memecyleæ the embryo is large with plano-convex or subfoliaceous cotyledons.

Seedlings.—The seedlings observed all belong to the suborder Melastomeæ having numerous small seeds, consequently the cotyledons even after germination are very small, or even minute in Rhexia Mariana (fig. 352). The lamina is only about 1–5 mm. long, by 1–2·5 mm. wide, shortly petiolate and rhomboid in outline. The first three or four pairs of leaves are broadly ovate, trinerved and gradually increase in size from the first pair which is very small or even minute. Several succeeding pairs are inclined to be elliptic and are serrate. Rhomboid cotyledons also occur in other genera and species, including Osbeckia rubicunda where they show a distinct midrib but no other venation. The latter species is notable for the length of the first internode. The first pair of leaves is roundly ovate, subcordate at the base and trinerved, while two or more succeeding pairs are inclined to be elliptic. Osbeckia capitata (fig. 351) has broadly ovate, one-nerved cotyledons; and the two forms given are likely to be the prevailing ones throughout a large number of the species with numerous small seeds. The first three pairs of leaves are ovate, while succeeding ones are inclined to be cordate at the base, and from the third pair onward they are five-nerved. Strong nerves proceeding from the base to the apex of the leaf are very prevalent and characteristic of the Order; but in Medinilla magnifica and M. amabilis, strong nerves are given off at various points along the midrib, and possibly in other species, where the venation is pinnate.

Osbeckia capitata, *Benth.* (fig. 351).

Primary root long, slender, tapering very gradually downwards, flexuose, and provided at an early stage with very short lateral rootlets.

Hypocotyl erect, terete, pubescent with very minute incurved hairs, almost colourless, and becoming pale red at an early stage, about 1 mm. long when the first leaves have appeared, and elongating little or none at all after this.

Cotyledons ovate, obtuse, entire, minutely pubescent, at least at the edges, petiolate, showing an indistinct midrib, but no other venation, deep green above and red beneath; lamina 1·5 mm. long, 1·25 mm. wide; petiole flattened above, convex on the back, rather broad, ·75 mm. long.

They do not increase much beyond these dimensions, but drop away after a time.

Stem erect, quadrangular; angles obtuse and densely covered with closely and upwardly adpressed, bulbous-rooted hairs, the intermediate faces smooth or more or less densely and irregularly covered with similar hairs, red, and ultimately shrubby; 1st internode 1·25–5 mm. long; 2nd 1·3–2 cm.; 3rd 1·1–1·6 cm.

Leaves simple, cauline, entire, opposite, exstipulate, petiolate, covered more or less densely on both surfaces with bulbous-rooted adpressed hairs directed towards the apex, deep green above, pale beneath or often stained with red; petioles very short, channelled above, densely hairy, slightly connate at the base, or forming a ring round the stem, with one to three or more stronger, erect bristles on the ring.

First pair of leaves small, ovate, obtuse, entire, trinerved, with comparatively longer petioles than succeeding ones.

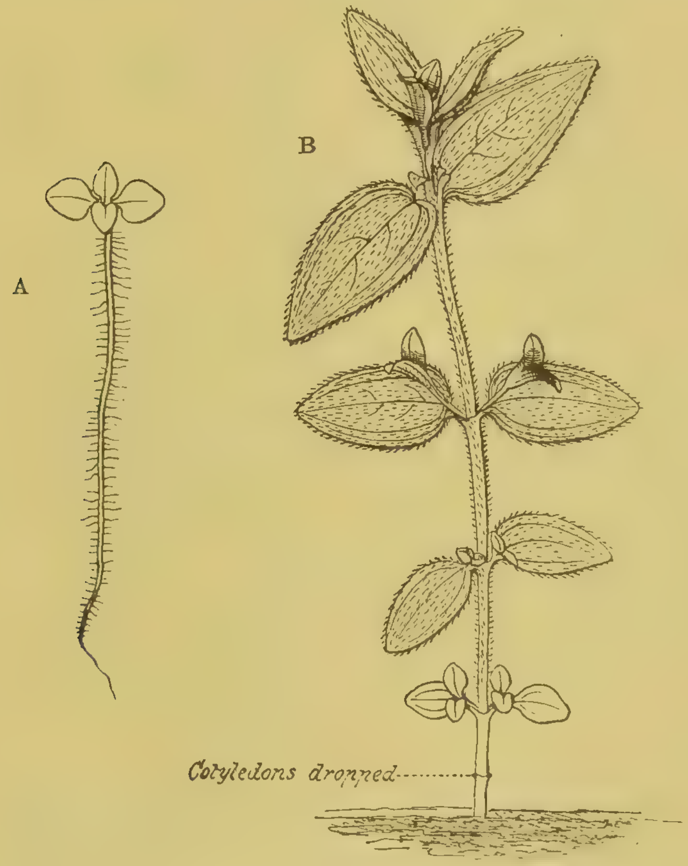

FIG. 351.—*Osbeckia capitata.* A, young seedling, × 4. B, older seedling. Nat. size

Second pair ovate, obtuse, strongly trinerved.

Third pair ovate, obtuse, strongly trinerved with sometimes two other slender nerves.

Fourth to sixth pairs similar, but gradually wider and subcordate at the base.

Rhexia Mariana, *L.* (fig. 352).

Primary root very long, slender, flexuose, colourless, furnished with numerous lateral rootlets.

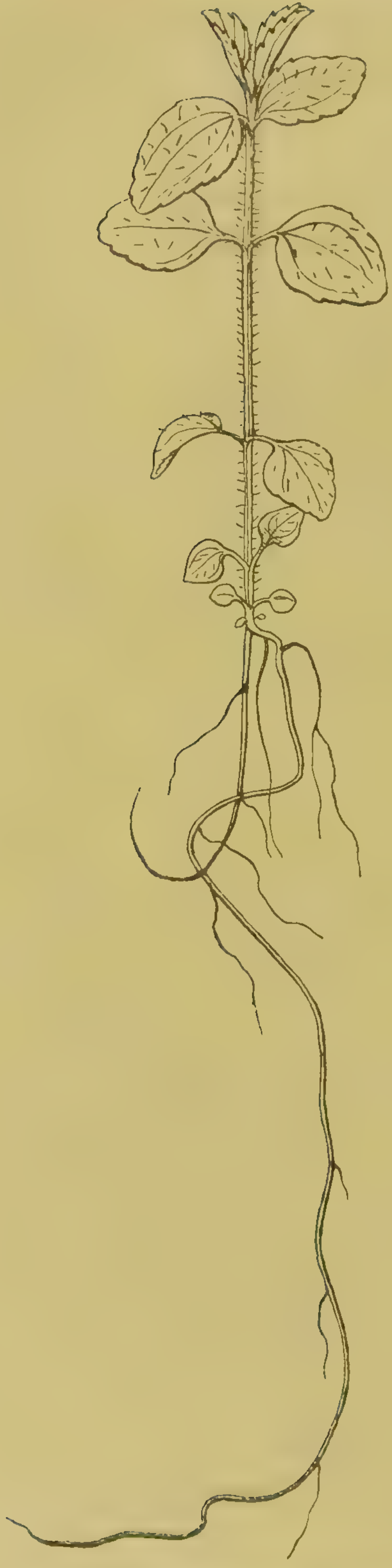

FIG. 352.—*Rhexia Mariana.* Nat. size.

Hypocotyl short and indistinguishable from the root.

Cotyledons minute, rhomboid, obtuse, glabrous, shortly petiolate, bronze red; lamina 1·5 mm. long, 1·25 mm. wide; petiole grooved above, 1 mm. long.

Stem herbaceous, erect, subterete, grooved on two sides from between the bases of the petioles downwards to the axils of the two lower leaves, coarsely hairy, or glandular-hairy when young, red; 1st internode 1·5 mm. long; 2nd 4 mm.; 3rd 1·4 cm.; 4th 2·05 cm.

Leaves simple, cauline, opposite, decussate, petiolate, exstipulate, coarsely and thinly glandular-hairy on both surfaces, trinerved, with the lateral nerves describing an ellipse, bronze green above, deep red and shining beneath; petioles channelled above, rounded on the back, red, very thinly glandular-hairy.

First pair very small, broadly ovate, obtuse, entire, indistinctly trinerved.

Second pair larger, similar.

Third pair broadly ovate, obtuse, minutely emarginate, and minutely apiculate in the notch when quite young, distantly serrulate.

Fourth to sixth pairs ovate-elliptic, obtuse, minutely emarginate and apiculate in the notch when young, serrulate.

LYTHRARIEÆ.

Benth. et Hook. *Gen. Pl.* i. 773.

Fruit and Seed.—The two- to six-celled ovary composed of as many carpels is mostly superior or free, rarely girt at the base by one or more glands, and still more rarely wholly immersed in the receptacle as in Punica and Axinandra. One-celled ovaries may arise by the destruction of the septa, or by one out of two carpels becoming suppressed. The ovules are numerous, multiseriate, anatropous, inserted on axile or basal, rarely parietal placentas. They are solitary in the cells of Axinandra, reduced to two in the one-celled ovary of Strephonema, and inserted on a free basal placenta in the one-celled ovary of Antherylium.

The fruit is capsular, two- to six-celled with axile placentas, or one-celled by the destruction of the septa when the placentas become free and central. Baccate fruits occur in Punica and Sonneratia which are in many respects anomalous for the Order. The first named has the walls of the fruit of a thick and leathery nature, while the seeds are surrounded by a deep layer of watery pulp. The interior is many-celled with the cells arranged in two tiers, one above the other. In other and more typical cases the seeds are smaller, and terete, angled or winged, exalbuminous or with a small quantity of endosperm. The testa varies in different species both in thickness and texture, and in some cases it is pilose or hispid.

The embryo is generally straight, with oblong or orbicular, flat, auricled cotyledons, varying in conformity with the shape of the seed. An exceptional case occurs in Dodecas which has small hispid seeds resembling sawdust, containing a slender, elongated embryo with linear cotyledons, and a terete radicle. The cotyledons of Punica are spirally convolute in the seed, and auricled at the base. A good type is represented by Cuphea silenoides (fig. 353). The cotyledons are suborbicular, deeply auricled at the base and distinctly emarginate, the emargination being due to a pronounced thickening at the slightly indented chalaza. The auricles are produced in order to occupy the space on each side of the radicle, which terminates abruptly in three rounded lobes. The reason for this peculiar form of the radicle is not very evident. The seed in transverse section is thinly elliptic.

Seedlings.—At least two well-marked types of cotyledons occur as well as a few striking exceptional instances. One type is represented by Cuphea silenoides (fig. 354). The cotyledons are roundly-triangular, emarginate, truncate at the base and faintly five-nerved. A remarkable point about them is that they are auricled at the base while still in the seed as above noticed, and for some time after germination; but as growth proceeds and they become fully developed the auricles become lost or obliterated by the more rapid growth of the lamina in the neighbourhood of their attachment to the petiole than in the auricles themselves. Similar examples are met with in species of Salvia belonging to the Labiatæ, but the obliteration of auricles already well-developed in the seed is by no means of frequent occurrence. They usually increase in size after germination. The primary causes of the auricles, and the emargination, are referred to above. The abrupt and sublobate condition of the hypocotyl in the seed shows itself after germination in the form of an annular thickening. C. Roezlii agrees generally with the type given, but the cotyledons are much smaller and subcuneate at the base when full grown; and the latter characteristic is no doubt due to growth subsequent to germination. This is carried to a still greater extent in Cuphea coccinea where the cotyledons are broadly obcordate with a cuneate base and trinerved. The first pair of leaves in all three cases is ovate and entire, and subsequent ones vary between oblong-elliptic or lanceolate, or remain unaltered except in size.

The second type is met with in Lythrum flexuosum and other species which have oblong-oval, obtuse cotyledons with a cuneate base. In L. flexuosum they are small, often slightly constricted near the apex and appearing obsoletely trinerved. Venation seems restricted to a faint midrib. The primary leaves at least are opposite, oblong-ovate, and decurrent on the stem, making it quadrangular or narrowly four-winged.

An exceptional case to the above types is met with in

Punica Granatum (fig. 355) which has transversely oblong, deeply emarginate, five-nerved cotyledons, rounded at the sides. The outer pair of nerves follows the outline of the cotyledons, parallel to the margin. Their great width is due to their being convolute in the seed, which is unusually large for the Order. The leaves are opposite, lanceolate, shortly petiolate and decurrent upon the stem, making it narrowly four-winged as in Lythrum. The thick testa of the seed splits open during germination owing to the rapid growth and expansion of the cotyledons.

Cuphea silenoides, *Nees* (fig. 353).

Fruit a capsule, oblong, straight or oblique, one-celled by rupture of the septum, with the free columnar placenta bearing numerous seeds on one side only, while the side representing the placenta of the smaller and empty cell is naked; dehiscing longitudinally along one side.

Seed shortly and broadly obovate, retuse, generally shallowly emarginate, much compressed, glabrous, dull slaty-blue marked with black dots; hilum and micropyle basal; chalaza apical, thickened for a short way internally, causing the cotyledons to be emarginate; raphe forming a visible ridge along one flattened face; testa thick, coriaceous; tegmen thin, membranous, whitish.

Endosperm absent.

Embryo straight, conforming closely to the interior of the seed which it fills, colourless; cotyledons orbicular, emarginate, rather deeply auricled at the base, plano-convex or nearly flat; auricles evidently produced to fill up the space in the seed, and give room for the radicle and plumule; radicle protruding slightly beyond the cotyledons, trilobate with the middle point turbinate and generally longer than the obtuse lateral points.

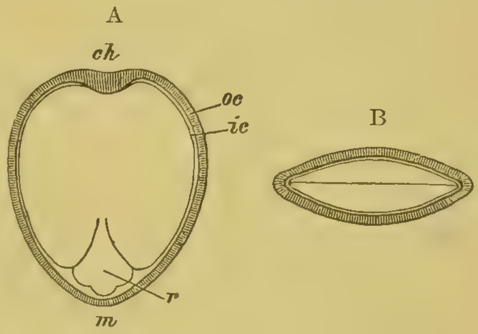

FIG. 353.—*Cuphea silenoides*, × 10 A, longitudinal section of seed: *ch*, chalaza; *oc*, testa; and *ic*, tegmen; *r*, radicle; *m*, micropyle. B, Transverse section of seed.

Seedling (fig. 354).

Primary root tapering, flexuose, much branched.

Hypocotyl erect, terete, glandular-hairy towards the upper end with red hairs, and densely covered with a minute, colourless, papillose pubescence, 1·6–2·8 cm. long.

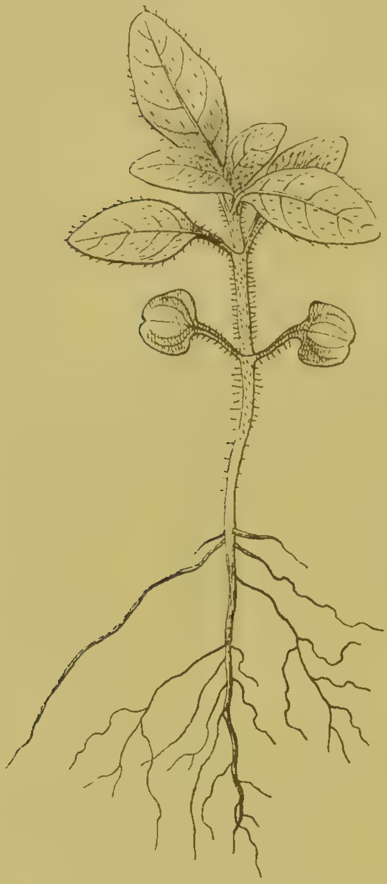

FIG. 354.—*Cuphea silenoides.* Nat. size.

Cotyledons rotund-triangular, obtuse, emarginate, more or less truncate at the base, petiolate, minutely puberulous at the margin and slightly glandular-hairy on the midrib beneath, light green; lamina 4·5–5·5 mm. long, 5·5–7 mm. wide; petiole widening slightly upwards, convex on the back, channelled above, glandular-hairy on the back, densely and minutely pubescent, 4–7 mm. long.

Stem herbaceous, annual, erect, terete, densely glandular-hairy with red hairs, and minutely pubescent with short, recurved, colourless hairs; 1st internode 7–13 mm. long, second shorter.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, alternately and ascendingly incurvinerved, covered on both surfaces with red glandular hairs, which afterwards become colourless, and minutely pubescent on both surfaces as well as the margin with colourless hairs directed towards the apex of the leaf; petiole short, channelled above, convex on the back, hairy like the leaf.

First pair ovate or oblong, obtuse.

Second and third pairs oblong or elliptic-oblong, obtuse.

Cuphea Roezlii, *Carr.*

Primary root normal.

Hypocotyl slender, erect, terete, glabrous.

Cotyledons as in last species, but slightly cuneate at the base and glabrous; lamina 3·75 mm. long, 4 mm. wide.

Stem shrubby, otherwise as in last species, pale green; 1st internode scarcely developed or short.

Leaves as in last species, but finely scabrous on both surfaces with minute bristly hairs; petioles scabrous, channelled and green above, paler on the back and rounded, glandluar-hairy on the margins of the channels, and slightly so all round at the base.

First pair ovate, acute, small.

Ultimate leaves ovate, acuminate, acute, or the upper lanceolate, all tapering to the base, rather opaque green, paler beneath.

Cuphea coccinea, *DC.*

Hypocotyl similar to that of C. silenoides, 3–5 cm. long, light green, colourless, or tinged with red.

Cotyledons broadly obcordate, emarginate, petiolate, glabrous except on the petioles, indistinctly trinerved.

Stem erect, herbaceous, hairy ; 1st internode about 1 mm. in diameter.

First leaves as in C. silenoides, hairy, light green, very shortly petiolate.

Lythrum flexuosum, *Lag.*

Primary root very long, slender, flexuose, fibrous.

Hypocotyl terete, glabrous, red, 4–12 mm. long.

Cotyledons oblong-oval, obtuse, cuneate at the base, petiolate, often slightly constricted near the apex and hence appearing obsoletely tridentate, glabrous, showing a midrib on the lower two thirds of its length only, 5–8 mm. long including the petiole, 3–4·5 mm. wide.

Stem herbaceous, erect (in the seedling stage at least), quadrangular or somewhat four-winged, glabrous, reddish ; 1st internode 1–4·5 mm. long.

Leaves simple, cauline, opposite in the seedling, exstipulate, sessile, glabrous, with a distinct midrib, and a few lateral, ascending indistinct nerves.

First and second pairs oblong-ovate, obtuse, entire, sessile, with their bases decurrent on the stem forming the wings.

Punica Granatum, *L.*

Fruit very large, globose, baccate, glabrous, somewhat roughened on the exterior, many-celled, many-seeded, indehiscent, crowned with the persistent tube and five- to seven-lobed lamina of the calyx on which the numerous stamens are persistent ; exocarp subcrustaceous, yellowish ; style persistent.

Seeds very large, variously angled by mutual pressure, and tapered more or less to a cuneate base, glabrous ; outer layer of testa resolved into a deep mass of watery, reddish pulp ; inner layer coriaceous or subcrustaceous when fresh, ultimately hard ; hilum and micropyle contiguous, basal ; chalaza apical.

Endosperm absent.

Embryo very large, straight, spirally convolute, colourless, occupying the whole interior of the seed; cotyledons broad, spirally convolute, unequally auricled, varying in the manner of folding in different seeds, one half of each cotyledon being turned inwards, the other half round the exterior of the coil and next to the testa, unequal-sided, but when spread out flat broadly oblong, obtuse, entire, with the exception of the basal auricles, or somewhat emarginate; larger auricle external to the coil; smaller one rolled up internally; radicle about half the length of the cotyledons, or a little more, fusiform and thinnest at the upper end which is covered with the cotyledons, tapered to a very obtuse point, and extending about 1–1·5 mm. beyond the cotyledons, and lying in the basal and pointed end of the seed.

Larger half of the cotyledon 4·5–5·5 mm. long; smaller one 3·25–4·5 mm. long; together 3–4·5 mm. wide. Radicle 3–3·5 mm. long.

Germination.—Immediately, or soon after the radicle makes its appearance, the testa is split longitudinally into two valves by the energy of the swelling cotyledons. Root-hairs are already present from the base of the hypocotyl downwards. When not very deeply buried, the testa is carried up by the elongating hypocotyl.

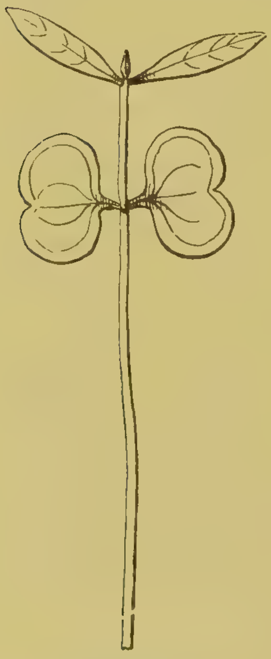

FIG. 355.
Punica Granatum.
Nat. size.

Seedling (fig. 355).

Hypocotyl long, erect, subquadrangular, glabrous, 2·5–3 cm. long, light green or colourless.

Cotyledons transversely oblong, emarginate, glabrous, with short flattened petioles, dark green, 1–1·3 cm. long including the short petioles, 1·4–1·55 cm. wide, with a prominent midrib and two lateral nerves running parallel to the sides, meeting the midrib at the apex, also two faint nerves between these and the midrib.

Stem herbaceous, ultimately becoming woody, erect, square, with winged edges, glabrous, pale green; 1st internode 5–15 mm. long.

Leaves linear-lanceolate, cuneate at the base, shortly petiolate, glabrous, light green; pinnatinerved.

ONAGRARIEÆ.

Benth. et Hook. *Gen. Pl.* i. 785.

Fruit and Seed.—The inferior ovary is four-celled in the more typical forms, but the number of cells varies from one to six, the ovary being one-celled when the septa are incomplete. The ovules are generally very numerous, anatropous, ascending or pendulous, and arranged in a single or double series, rarely in many series, upon the axile placentas. In Diplandra, Circæa, Trapa, Gaura, Heterogaura and Gongylocarpus the ovules are solitary and pendulous or ascending, in each cell, while the one-celled ovary of Stenosiphon, a monotypic genus from Texas, contains four pendulous ovules. The fruit is capsular, less often baccate as in Fuchsia, or nut-like as in Trapa. Capsular fruits are very frequently elongated and cylindrical, or quadrangular, dehiscing septicidally, or loculicidally by four longitudinal valves.

The seeds are numerous or few according to the number of ovules, but vary in number, and somewhat in size, even within the limits of a genus, as, for instance, in Œnothera; they are for the most part comparatively small, those of Trapa being exceptionally large. The testa is thin, membranous or coriaceous, and smooth or papillose, with the papillæ hard when the seeds are mature. The seeds of Epilobium are comose at the apex as frequently occurs in the Asclepiadeæ, or at one or both extremities of the seeds of the Apocynaceæ and Salicineæ. Endosperm is wanting or is reduced to a thin stratum as in some species of Œnothera and Eucharidium. The embryo is generally obovoid, and conforms to the interior of the seed. The cotyledons are plano-convex, compressed, sometimes slender, rarely curved and very rarely convolute; and the radicle is short and straight, rarely curved as in Trapa.

The fruit of the last-named genus is very exceptional, being nut-like, turbinate, and terminated by two or four spines, one-celled, one-seeded and indehiscent. The testa is spongy, and very much thickened in the upper part. The embryo is very remarkable in having one very large cotyledon, and one minute scale-like one.

A good type of the Order is represented by Clarkia sp. (fig. 356) which has amygdaloid cotyledons slightly emarginate and cordate at the base. The emargination is due to a slight thickening at the chalaza, and the basal auricles are produced to occupy the space on each side of the base of the radicle. The seeds of Œnothera Lindleyana are similar, but show greatly elongated papillæ at the chalaza. In Œ. biennis (fig. 364) the embryo is generally amygdaloid and entire. Instances occur where the cotyledons are slightly convolute with the edge of the one folded within that of the other. The testa shows a remarkable thickening in places, while elsewhere it is comparatively thin. The embryo of Eucharidium grandiflorum is like those of Clarkia sp. and Œnothera Lindleyana, except that the base of the cotyledons is more deeply auricled. There is a strongly developed crest at the apex of the seed, passing round the chalaza, and extending nearly to the hilum, and it is fringed at its margin with papillæ throughout.

Seedlings.—The cotyledons of the various seedlings of this Order show great variation, both in size and outline, and in being entire or variously crenate, dentate, serrate or constricted at the margin, even within the limits of a single genus, so that it is often impossible to classify species of allied genera under any one group. Two very distinct kinds, however, may be noted, namely those which are small or generally so and entire, and secondly, those which attain a comparatively large size by intercalary growth whether entire or variously cut. To the first group belongs Epilobium angustifolium which has small ovate, entire, obtuse, shortly petiolate cotyledons, showing no other venation than the midrib. Here also may be grouped a number of species of Œnothera; but for the sake of comparison with other species it is convenient to describe them under that genus.

Cotyledons that exhibit intercalary growth, and especially if they attain any size, partake of two natures, and that often in a marked manner. The upper part is the true cotyledon, while the lower part, which is generally much the larger, is of the nature of a true leaf, and varies in shape according to that of the latter as exhibited in the primary leaves with the margin similarly entire or toothed, and smooth or hairy. Most often also there is a distinct constriction between the true cotyledonary portion and the foliar one; and the former retains the apical notch or emargination it may have possessed while still in the seed.

One of the simplest forms coming under observation and showing a marginal constriction where intercalary growth commences, is that of Lopezia coronata with ovate cotyledons, the basal and foliar portion of which widens so as to produce a tooth on each side. Fuchsia corymbifolia is somewhat similar, but the cotyledons are emarginate. A very different form is met with in Clarkia pulchella (fig. 361) which has ovate, minutely emarginate, but otherwise entire cotyledons. The foliar portion is indicated only by being minutely ciliate at the margin like the first true leaves, and by the petiole; the cotyledons proper in the early stages being sessile, as in all the types mentioned below. The cotyledons of Clarkia sp. (figs. 357, 358) after germination are sessile, suborbicular, emarginate, and vary to obcordate with a tooth in the notch, gradually becoming petiolate and then oblong, constricted in the middle, then panduriform, and ultimately rhomboid-ovate and serrate below the constriction. The upper portion retains its original form almost to the last, and constitutes but a very small portion of the cotyledon when fully developed. By unequal growth of the two sides of the stem the cotyledons in many individual seedlings become alternate. A similar development obtains amongst many of the species of Œnothera and other genera. C. integripetala (fig. 362) differs chiefly in the upper surface of the cotyledons being minutely and papillosely pubescent all over, and in the two portions being separated by a transverse brown line. The pubescence is present in C. rhomboidea (fig. 360), but the minute, marginal cilia are carried entirely round the cotyledons which are oblong-ovate and entire in the foliar portion, thus corresponding to the primary leaves as in all other cases where intercalary growth prevails. The cotyledons of Eucharidium concinnum differ from those of the last named in being broadly ovate, obsoletely crenate below the constriction, and ciliolate there only. Those of E. grandiflorum differ from those of its congener in the upper surface being glabrous except at the very base. It will thus be seen that the species of Clarkia and Eucharidium differ from one another either in the shape of the cotyledons, the marginal toothing, or the distribution of the cilia or pubescence.

The seedlings of Œnothera exhibit a great amount of variation in different species; but they may be arranged in groups, possessing well-recognised bonds of affinity. Those observed may be grouped under six types. The first is represented by Œ. fruticosa. The plants are perennial with yellow flowers, small, pale brown, smooth seeds, and diminutive slow-growing seedlings, with broadly or roundly ovate, or rotund-elliptic, entire cotyledons that scarcely differ from one another, and exhibit no distinct foliar innovation or intercalary growth. Other species agreeing with Œ. fruticosa are Œ. pumila, Œ. glauca, Œ. serotina, Œ. linearis and Œ. rosea. The cotyledons of the latter are more truncate at the base of the lamina in some stages than the rest.

The second type is represented by Œ. taraxacifolia (fig. 363). Both the seeds and seedlings are large, the plant perennial, and the cotyledons oblong, emarginate, cuneate at the base with long petioles, glandular-pubescent all over, and mostly entire. In this latter respect they are very exceptional, inasmuch as the primary leaves are obsoletely dentate. Sometimes a small tooth is discernible on each side giving an indication perhaps of the foliar nature of the lower portion.

The third group consists of biennials with comparatively large variously compressed and angled seeds, and an irregularly thickened subcrustaceous testa as mentioned under 'Seeds' (p. 554). The seedlings are robust, and the cotyledons are broadly ovate, obtuse, and indicate foliaceous, intercalary growth in the lower portion by the venation, the ciliated margin, and more or less by a shallow constriction above the middle or a small tooth on each side. The constriction and the teeth are rather obscure however in many cases. This type is exemplified by Œ. biennis (fig. 365). An exception to the general form of the cotyledons while yet in the seed was mentioned above, and in the seedling state individuals occur with unequal cotyledons due to contortion or folding in the seed. Œ. Lamarckiana agrees with this type, but the cotyledons are generally quite entire.

The fourth type consists of annuals represented by Œ. stricta (fig. 366). The seeds are of medium size with a membranous reticulate testa, and the seedlings are vigorous, exhibiting a distinct foliar development in the lower portion of the cotyledons by the venation, the finely ciliate margin, and by a distinct tooth above the middle on each side. The cotyledons at different stages of growth vary from oblong to ovate, broadly ovate, spathulate, and finally oblong-obovate or subrhomboid.

The fifth type consists of annuals with purple flowers, large rugose or papillosely punctate seed, margined or winged at the chalaza, and sometimes around the raphe. The seedlings are large, vigorous and rapid in growth, while the large cotyledons show a marked foliar, intercalary growth such as occurs in Clarkia sp. and C. integripetala above mentioned. This type of Œnothera is well exemplified by Œ. Lindleyana. The cotyledons exhibit the same phases of growth as Clarkia sp. (figs. 357–8), and ultimately become broadly ovate, emarginate with a tooth in the notch, constricted about the middle with two or three teeth on each side below that and finely ciliate. Œ. amœna agrees pretty closely with this type, but the cotyledons are finely pubescent all over. Œ. tenella quadrivulnera has somewhat variable cotyledons. The commoner forms are obovate-cuneate and frequently alternate in the ultimate stage as in Clarkia sp. (figs. 357–8). Another form has obovate-oblong cotyledons with the other characters of the type given. Œ. Romanzowii has obovate cotyledons, considerably tapered to the base in the ultimate stage, and often alternate. The upper or true portion of the cotyledons is much the broader in this species as well as in Œ. tenella quadrivulnera, a condition contrary to the general rule in the group. Œ. purpurea and Œ. cheiranthifolia agree with the other species of this group in all main particulars, and particularly in the lower portion of the cotyledons being of a foliaceous nature.

The sixth group corresponds to the subgenus Sphærostigma, as the fifth did to that of Godetia. Œ. macrantha (fig. 369) shows the foliar evolution of the cotyledons in this group.

The true portion remains small and nearly orbicular and glabrous from first to last, while the leafy portion is linear, obscurely dentate, ciliate and gradually increases in length so as to resemble the true leaves, except in being somewhat narrower. Œ. contorta differs somewhat in the foliar portion being very narrow, distinctly crenate-dentate with opposite teeth, in all respects, however, resembling the primary leaves. Œ. bistorta (figs. 367, 368) strongly resembles Œ. macrantha, but more stages of development are shown. Œ. hirta bears some resemblance to Œ. contorta, but the foliar portions of the cotyledons like the true leaves are very hairy, while the upper or true portion is smooth.

Clarkia sp. (fig. 356).

Fruit a capsule, linear, quadrangular, attenuated at the apex, dehiscing to the middle by four longitudinal valves, four-celled, many-seeded.

Seed narrowly obovoid, small, flattened on that side to which the raphe is attached; testa thick, coriaceous, papillose all over, dark brown; raphe running along a flattened surface; chalaza apical, somewhat thickened externally and internally to the seed; hilum and micropyle basal, contiguous.

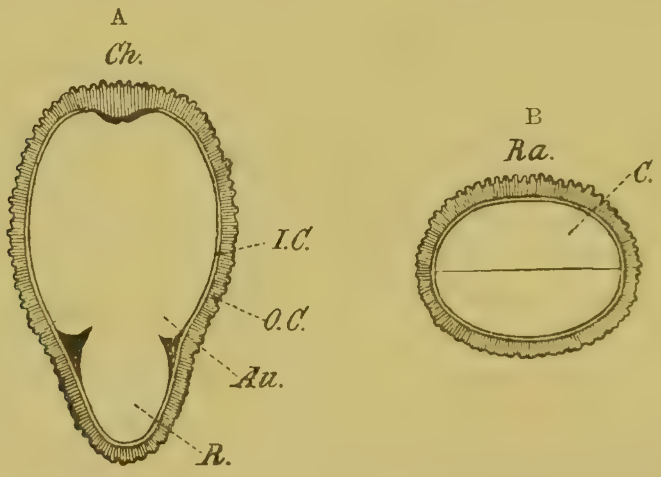

Fig. 356.—*Clarkia sp.*, × 24. A, longitudinal section of seed: *Ch*, chalaza; *IC*, tegmen; *OC*, testa; *Au*, auricle; *R*, radicle. B, transverse section of seed: *Ra*, position of raphe; *C*, cotyledon.

Endosperm absent.

Embryo straight, large for the seed which it completely fills, colourless; cotyledons broadly oblong, minutely emarginate with a tooth in the notch, auricled or cordate at the base, plano-convex, and conforming to the interior of the seed, lying in the broader way of the slightly compressed seed, with their backs to the raphe; radicle much shorter than the cotyledons, turbinate, obtuse, lying in the basal and pointed end of the seed, much longer than the auricles of the cotyledons.

Seedling (figs. 357, 358).

Primary root long, tapering downwards, and giving off short lateral rootlets, colourless, annual.

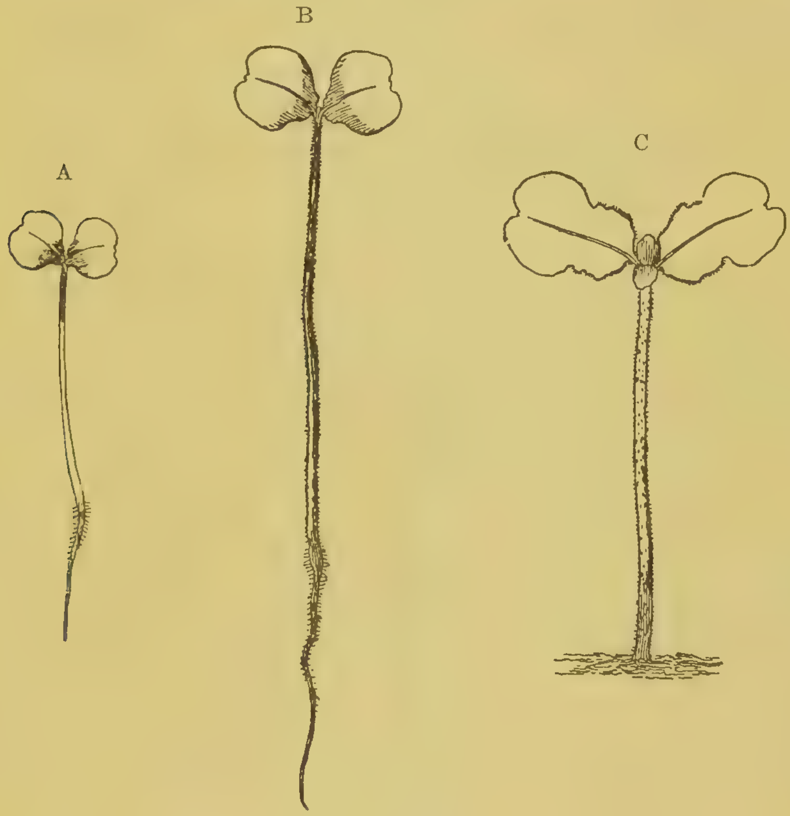

FIG. 357.—*Clarkia sp.*, × 2.

Hypocotyl erect, terete, densely and minutely pubescent, deep red, 2·5–3·5 cm. long.

Cotyledons rhomboid-ovate, emarginate, with a tooth in the notch, distantly toothed at the sides, and constricted some distance below the apex, with narrow rounded notches, and a distinct midrib but no other discernible venation in the fresh state, petiolate, glabrous excepting the petiole, deep green above, glaucous beneath; lamina 8–14 mm. long, 6·5–10 mm. wide; petiole subterete, shallowly grooved above, minutely pubescent, pale green or reddish especially on the midrib.

Stem erect, terete, minutely pubescent, pale green, annual; 1st internode 9–12 mm. long.

Leaves simple, cauline, lower opposite, upper alternate, exstipulate, petiolate; glabrous or very nearly so excepting the petioles, alternately incurvinerved, deep green above with a deep red or crimson midrib, paler beneath or glaucous; petiole semiterete, rather deeply channelled above, minutely pubescent, slightly connate at the base, or forming a ring round the stem where the leaves are opposite.

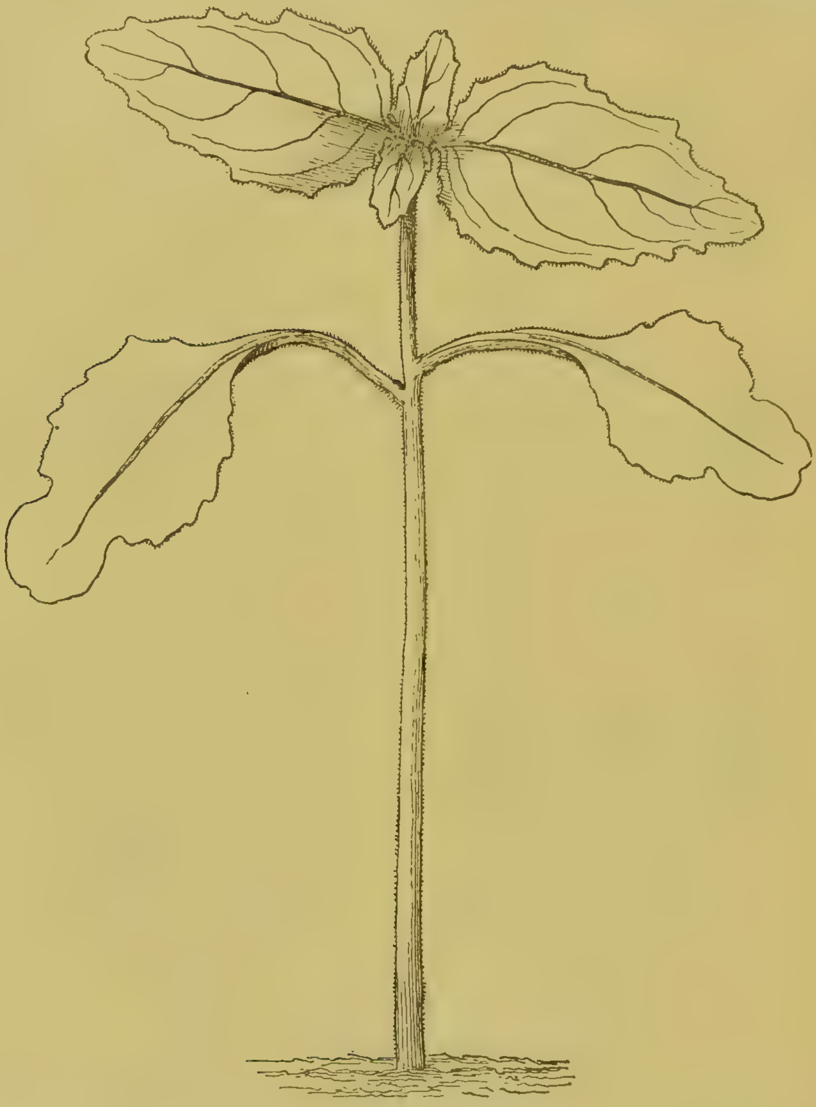

FIG. 358.—*Clarkia sp.*, × 2.

First pair of leaves ovate, obtuse, alternately incurvinerved, distantly and shallowly serrate-dentate, often minutely tricuspidate or tridentate at the apex.

Second pair narrower, oblong-ovate, otherwise similar to the first.

DEVELOPMENT OF THE COTYLEDONS.

The cotyledons immediately after germination are oblong-orbicular, minutely emarginate, with a small tooth in the notch, slightly auricled at the base, sessile, with a scarcely discernible midrib.

They then enlarge, become orbicular or broadly obovate, subcuneate at the base, and shortly petiolate. Fig. 357, A, shows a specimen three days after germination.

A change now occurs at the base of the cotyledons, which is at first narrower and soon becomes conspicuous by the presence of a small tooth on each side, as is shown in Fig. 357, B, which represents a seedling five days after germination.

The new portion elongates, bearing two to four teeth on each side, and the whole cotyledon becomes oblong, with a broad emarginate upper half consisting of the true cotyledon, and a basal narrower half which is truly foliolar with the characteristic white and reddish midrib of the true leaves, and the marginal teeth; petiole now 1·5–2 mm. long. (Ten days after germination.) (Fig. 357, C.)

The cotyledons now become broadly ovate, cuneate at the base, petiolate, and all or most of them more or less distinctly alternate; the lower part or innovation has four to six small obtuse teeth on each side, and is broadly subelliptic in outline, minutely ciliate at the margin. The upper part or true cotyledon is comparatively small, suborbicular, emarginate, with a tooth in the notch. (Eighteen days after germination.)

Clarkia rhomboidea, *Douglas* (figs. 359, 360).

Seeds 1·25–1·5 mm. long, and as wide near the apex.

DEVELOPMENT OF COTYLEDONS.

The cotyledons are at first orbicular, entire or faintly emarginate with a prominent apical tooth, sessile, and like the hypocotyl purplish, glabrous, but soon become minutely papillosely pubescent.

Nine days after germination (fig. 359) they are obovate or subpanduriform, emarginate with a small tooth in the notch, constricted below the middle, denoting the line between the upper part or true cotyledon which is minutely pubescent, and the lower part or innovation which is much more conspicuously pubescent with a pale pink or purplish midrib ending in a broader purple blotch on the base of the true cotyledon. Hypocotyl densely pubescent.

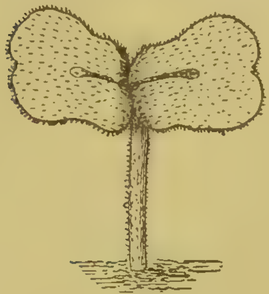

FIG. 359.
Clarkia rhomboidea, × 3.

The lower foliar portion soon becomes broader and longer than the upper cotyledonary part which is also only very slightly pubescent.

Thirty-five days after germination (fig. 360) the cotyledons are oblong, distinctly petiolate, constricted near the apex at the union of the foliaceous and cotyledonary part, emarginate with a minute tooth in the notch, cuneate at the base, with a distinct midrib throughout, and a few rather indistinct alternate nerves on each side, minutely pubescent all over the upper surface but more sparingly on the under surface, which is reddish-purple; petiole semiterete, channelled above, densely pubescent.

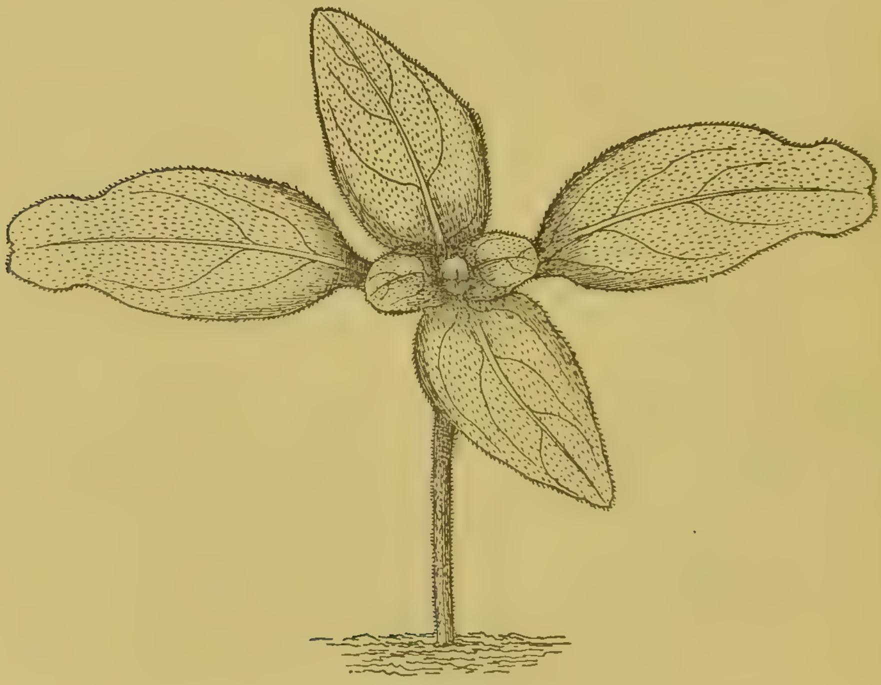

FIG. 360.—*Clarkia rhomboidea*, × 2.

First pair of leaves opposite, ovate, obtuse, cuneate at the base, alternately incurvinerved, entire, shortly petiolate, densely pubescent all over; petiole convex on the back or semiterete, channelled above, densely pubescent.

Second pair similar.

Clarkia pulchella, *Pursh* (fig. 361).

Primary root as in C. sp., p. 559.

Hypocotyl erect, terete, or thicker under the cotyledons, and tapering downwards, glabrous, 1–1·5 cm. long.

Cotyledons two rarely three, ovate, obtuse, foliaceous, glabrous, opaque green with a strong midrib, pale beneath ; lamina 14 mm. long, 8 mm. wide ; petiole channelled above, semiterete, minutely pubescent on the midrib beneath and at the margins above, about 4 mm. long.

Stem as in C. sp.; 1st internode 2·5 mm. long.

Leaves cauline, opposite, decussate, glabrous or minutely pubescent, especially on the nerves, subfleshy, opaque green, with a stout midrib ; petioles semiterete, minutely pubescent, slightly channelled above.

First pair oval-elliptic, obtuse, with two very small lateral nerves visible near the base.

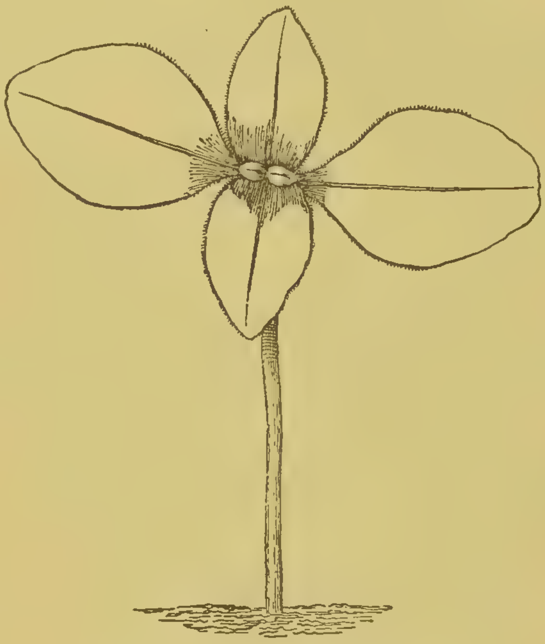

Fig. 361.—*Clarkia pulchella*, × 2.

Second pair oval, obtuse, with two or four distinct lateral nerves near the base, ultimately as they approach the full size narrowly elliptic.

Third to sixth pairs, ditto.

When there are three cotyledons, the leaves are in whorls of three, and there are axillary buds in the axils of both cotyledons and leaves.

DEVELOPMENT OF THE COTYLEDONS.

Immediately after germination the cotyledons are oblong-oval, entire with a slightly prominent colourless tooth at the apex of the midrib, sessile and very shortly auricled at the base.

Eleven days after germination they are broadly ovate, emarginate with a tooth in the notch, almost rounded at the base and very shortly petiolate. The innovation is distinguishable from the true cotyledon only by being minutely ciliate at the margin and by possessing a distinct sunken midrib like the true leaves.

Finally they become elliptic, emarginate with a minute tooth in the notch, tapering most to the base and petiolate, minutely ciliate on the margin and petiole, without any toothing (fig. 361).

Clarkia integripetala, ? *Hort.* (fig. 362).

Seeds 1·25–1·75 mm. long, ·75–1 mm. wide.

Cotyledons immediately after germination shortly oblong, obtuse, emarginate with a minute tooth in the notch, shallowly auricled at the base, sessile, glabrous.

Hypocotyl with a few minute glands.

Primary root furnished with root-hairs.

The day after germination the cotyledons have become transversely oval, and a shallow semicircular depression, and a grey midrib have appeared at the base of each.

Next day a tooth on each side near the cuneate base denotes the point where the true cotyledon ends, and the foliar portion begins, and four days after germination they are obovate and very shortly petiolate; upper part oblate, emarginate, with the apical tooth now almost obsolete: lower part rotund-subcuneate with one to two small teeth on each side, shorter and narrower than the upper part, minutely and papillosely pubescent.

Eight days after germination they are as a whole oblong, distinctly petiolate; upper part oblate, emarginate with the tooth in the notch almost obsolete; lower part broadly oblong with three to four minute teeth on each side, and a distinct reddish or silvery midrib, minutely pubescent and ciliolate, suddenly narrowed into the petiole. Hypocotyl long, minutely pubescent.

Seventeen days after germination (fig. 362) the lower part is broadly ovate with three to five teeth on each side and one to two pairs of very faint somewhat curved nerves running towards the marginal teeth, and a silvery midrib terminated above by a transverse brown line, papillosely pubescent all over; upper part oblate or oval, emarginate, with a tooth in the notch, minutely and much less conspicuously pubescent than the lower part; petioles semiterete, channelled above, shortly pubescent all over. Hypocotyl pubescent.

First two leaves opposite, equal, obtusely serrate, ovate, obtuse, oppositely and alternately incurvinerved, pubescent all over, petiolate.

Œnothera fruticosa, *L.*

Seeds 1·25-1·5 mm. long, ·33–·5 (rarely ·75) mm. wide.

Primary root tapering downwards and furnished with lateral fibres, ultimately superseded by strong adventitious roots from below and above the cotyledonary node.

Hypocotyl very short and soon becoming indistinguishable from the root.

Cotyledons variable in outline, with two or three alternate, flexuose, incurved nerves on each side of the midrib discernible only by transmitted light, glabrous, deep green above, paler beneath; lamina 4–5·5 mm. long, and about as broad except when ovate; petiole semiterete, shallowly channelled above, glabrous, slightly connate at the very base, 2·5–6 mm. long.

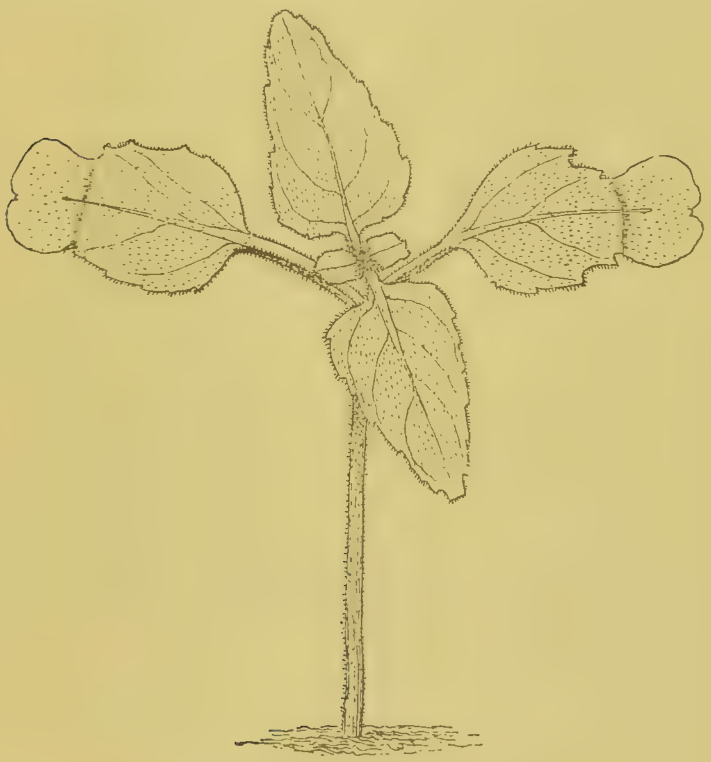

Fig. 362.—*Clarkia integripetala*, × 2.

Stem herbaceous, and developing when about to flower, firm and suffruticose; primary internodes undeveloped.

Leaves simple, almost entire, or obsoletely dentate with the teeth often hardly evident, radical and cauline, alternate, exstipulate, petiolate, alternately incurvinerved, obscurely reticulate, glabrous or with a few scattered hairs on the margins of the leaves and petioles in a young state; deep green above, paler beneath, thin but subcoriaceous and shining on both surfaces; petioles semiterete, channelled above, dilated and semiamplexicaul at the base of the radical ones, thinly ciliate at the margin with incurved hairs.

Nos. 1 to 4. Elliptic, or broadly oval, obtuse, the first or second sometimes apiculate, more or less cuneate at the base.

Nos. 5 and 6. Gradually more oblong, obtuse, tapering to the base.

Cotyledons immediately after germination rotund-ovate, entire, sessile or subsessile.

Eight days after germination they are rotund-ovate, or very broad, and deltoid, obtuse, rounded and entire at the apex, slightly cordate or almost truncate at the base, with a distinct channelled petiole about 1–1·5 mm. long.

The ultimate form of the cotyledons of this species is evidently subject to variation, but they never attain any great size as in the annual species. They vary from rotund to broadly elliptic, or ovate or deltoid, obtuse, more or less suddenly cuneate at the base, petiolate, and sometimes angled at the sides in the larger ones, which is the only evidence or trace of an innovation in this species. Like the leaves they are glabrous.

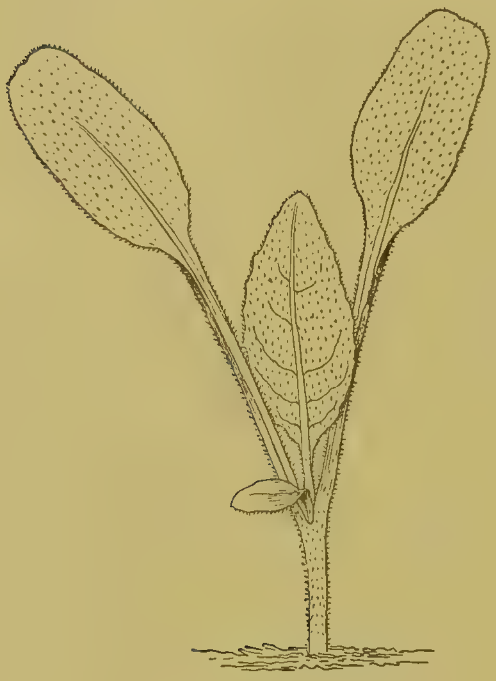

Fig. 363.—*Œnothera taraxacifolia*, × 2.

Œnothera rosea, *Ait.*, resembles the foregoing very closely.

Œnothera taraxacifolia, *Sw.* (fig. 363).

Seeds 2·5–3 mm. long, 1·25–1·5 mm. wide.

DEVELOPMENT OF COTYLEDONS.

The cotyledons immediately after germination are oblong, obtuse, entire, sessile, glandular-pubescent on the upper surface.

Eight days after germination they are oblong and obtuse, very shallowly emarginate, with long petioles, glandular-pubescent all over, tapering to the base; petiole semiterete, channelled above, densely and shortly glandular-pubescent.

Sixteen days after germination (fig. 363) the cotyledons are much larger, with longer petioles, and rarely show a minute tooth towards the base, otherwise the same.

Hypocotyl glandular-pubescent.

First leaf alternate, lanceolate, obtuse, petiolate, alternately incurvinerved in the upper half, and suboppositely incurvinerved in the lower, obtusely and obsoletely dentate at the margin, glandular-pubescent.

Œnothera biennis, *L.* (fig. 364).

Fruit a capsule, oblong or cylindrical, four-celled, many-seeded, dehiscing by four valves longitudinally and loculicidally, separating also from the axis, rigid or becoming woody when dry.

Seeds extremely variable in outline, oblong, obovoid, variously compressed and angled, often short, deep brown; testa variously thickened on one or two sides, but especially at all the projecting angles, corky, brown or almost black; tegmen thin, membranous, whitish; hilum and micropyle contiguous, basal; raphe passing along one of the thickened sides; thickening corresponding to the chalaza, not quite apical, but a little on one side.

Endosperm absent.

Embryo straight, comparatively large and filling the interior of the seed, colourless; cotyledons normally oblong, obtuse, minutely auricled at the base, sessile, plano-convex, lying in the broader way of the seed when the latter is in any way compressed, with their backs to the raphe or their edges to it, variable; radicle shorter than the cotyledons, or about one third the length of the whole embryo, turbinate, obtuse, and projecting beyond the auricles of the cotyledons, lying in the generally pointed base of the seed.

NOTE.—Another very prevalent form of embryo has one of its cotyledons, or sometimes both, involute.

Seedling (fig. 365).

Primary root tapering, flexuose, furnished with flexuose fibres.

Hypocotyl partly subterranean, terete, glabrous, reddish, 2–4 mm. long (when germinated in the open ground).

Cotyledons ovate, obtuse, shortly petiolate, glabrous, with a prominent midrib, and ascending incurved anastomosing lateral nerves (the latter seen only when the cotyledons are colourless and decaying), deep green or stained red in cold weather, 3·25–6 mm. long exclusive of petiole, 2–4 mm. wide; petiole channelled above, perfoliate at the base, ·75–1·5 mm. long.

Stem herbaceous and developed when about to flower, biennial.

Leaves simple, entire, radical and cauline, alternate, exstipulate, petiolate, glabrous in seedling, hairy on both sides in the adult, alternately and ascendingly or subincurvedly penninerved, with a prominent midrib; petioles flattened above or subchannelled on the cauline leaves, somewhat dilated at the base.

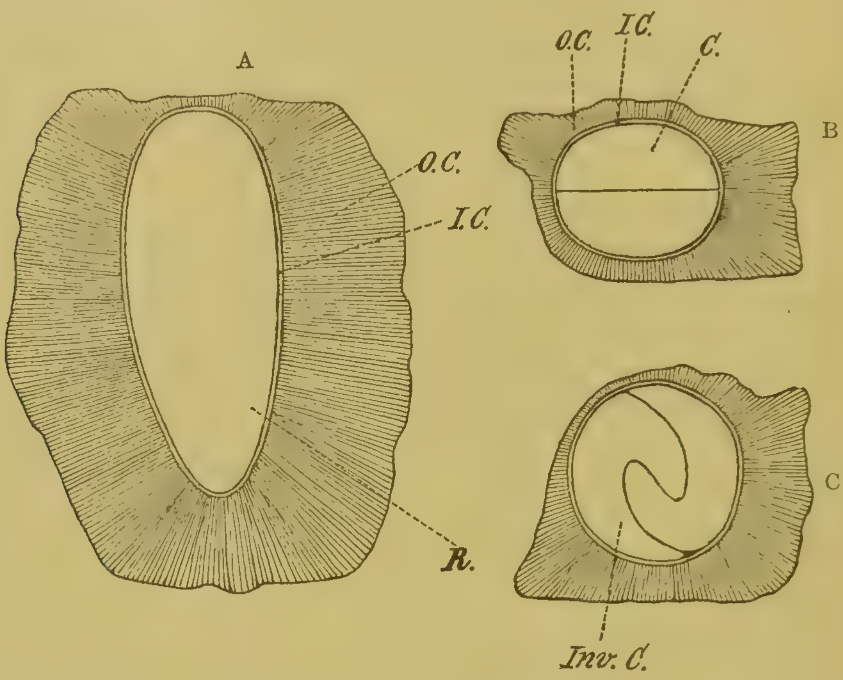

FIG. 364.—*Œnothera biennis*, × 28. A, longitudinal section of seed: *OC*, testa; *IC*, tegmen; *R*, radicle. B, transverse section of seed: *OC*, testa; *IC*, tegmen; *C*, cotyledon. C, transverse section of another common form of embryo and seed: *Inv. C*, involute cotyledon.

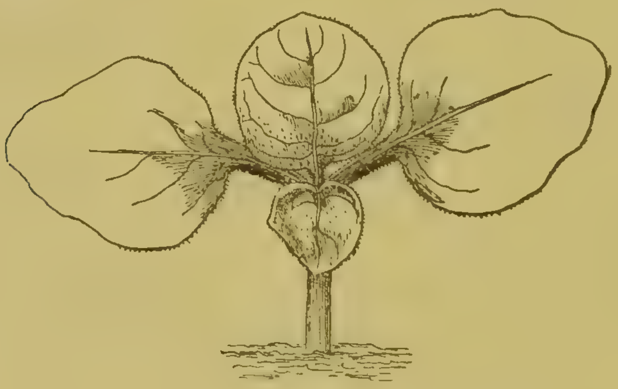

FIG. 365.—*Œnothera biennis*, × 2.

Nos. 1 and 2. Ovate, obtuse or subacute, shortly petiolate.

Ultimate radical leaves oblong, acute, tapered for some considerable distance at the base into the petiole; cauline shortly tapered at the base, oblong, acute, with a short petiole, all having the nerves ascending and incurved towards the tip where they unite with those next above them after having become exceedingly fine.

DEVELOPMENT OF THE COTYLEDONS.

(*a*) Immediately after germination the cotyledons are broadly ovate or oval-ovate, obtuse, entire, with a slightly prominent colourless tooth at the apex of the midrib, flat and subsessile.

(*a′*) Another form about equally common at this stage has the cotyledons involute, with one edge inside and the other outside—rarely with both edges inside the other cotyledon.

(*b*) Nine days after germination they become broadly ovate, obtuse, and entire with an innovation at the base not separated from the true cotyledon by a constriction as in several other species, but by a minute tooth on each side, and distinguished by being ciliate with incurved hairs, while the upper part is glabrous. Petiole 1·25–1·5 mm. long, and ciliate or pubescent.

(*b′*) The unequal ones still maintain their inequality. Larger one deltoid or rotund, very obtuse, shallowly cordate at the base, with the innovation ciliated with incurved hairs, while the upper part is glabrous, marked with a minute or obsolete tooth on each side. Smaller cotyledon narrower and less rounded.

(*c*) Sixteen days after germination the equal cotyledons are still ovate, obtuse, equal at the base, petiolate with the innovation thinly ciliate at the margin.

(*c′*) The unequal cotyledons are broadly ovate or deltoid, obtuse, entire, generally very unequal at the base, but the two are often dissimilar in that respect, ciliated with incurved hairs on the lower larger part corresponding to the innovation (fig. 365).

Œnothera Lamarckiana, *DC.*

Seeds 1·5–2 mm. long, 1–1·5 mm. wide.

DEVELOPMENT OF COTYLEDONS.

The cotyledons immediately after germination are oblong or broadly ovate-oblong, obtuse, entire, sessile and glabrous. Hypocotyl short and glabrous. Primary root simple, with root-hairs.

Ten days after germination the cotyledons are ovate, obtuse, entire, shortly petiolate, ciliate in the lower part with incurved short hairs. Petioles pubescent. Hypocotyl pubescent.

Twenty-three days after germination they are broadly ovate, obtuse, entire, rather suddenly narrowed above the middle, with rather long petioles; upper part glabrous, without a discernible midrib; lower part pubescent at the margins with incurved hairs, and a distinct midrib; petiole semiterete, channelled above, pubescent with incurved hairs. Hypocotyl short, now rather stout, glabrous.

First and second leaf very broadly ovate, sometimes broadly oblong, obtuse, entire, alternately incurvinerved, thinly pubescent all over and at the margin with incurved hairs, petiolate.

Œnothera stricta, *Ledeb.* (fig. 366).

Seeds ·5–1 mm. wide or thick, 1·25–1·5 mm. long.

DEVELOPMENT OF COTYLEDONS.

The cotyledons immediately after germination are oblong, obtuse, slightly auricled at the base, otherwise entire, sessile, thinly glandular-pubescent on the upper surface and ciliate. Hypocotyl thinly and minutely glandular-pubescent, short. Primary root simple, furnished with root-hairs.

Five days after germination they have become oblong-ovate, obtuse, shortly petiolate, thinly glandular-hairy.

Eight days after germination they are more distinctly petiolate, cuneate at the base, and sometimes with a minute but distinct tooth below the middle on each side, denoting the line of demarcation between the upper part or true cotyledon and the lower leaf-like part, thinly glandular-hairy and ciliate.

Twenty-nine days after germination they become spathulate-obovate or oblong-obovate, obtuse, with a tooth at the union of the foliar with the cotyledonary part on each side, glabrous except the petioles; upper part without a distinctly visible midrib; lower part tapering much to the base; petiole semiterete, flattened above, or shallowly channelled towards the apex, minutely and thinly puberulous, connate at the base. Hypocotyl stout, thinly pubescent. First five leaves at least radical, alternate, lanceolate, obtuse, tapering into the petiole, obsoletely and distantly toothed at the margins, alternately incurvinerved, with a conspicuous whitish or colourless midrib, glabrous except the petioles which are semiterete, flattened above or shallowly channelled, dilated at the base.

Œnothera Lindleyana, *Douglas.*

Fruit a narrowly oblong capsule.

Seed small, varying in shape and size, obovoid or oblong-obovoid, proportionately broad, or on the other hand narrow, sometimes angled; testa thin, dark-coloured, marked with black spots and pale on the ventral aspect, with two decurrent lines of papillæ from the chalaza at the apical end of the seed where the papillæ are longest and form an appendage or crest; micropyle at the narrow and basal end of the seed; raphe ventral.

Endosperm forming a very thin layer surrounding the embryo, thickened somewhat at the chalaza.

Embryo straight, large, nearly occupying the whole interior of the seed, and conforming to it in shape, more or less obovoid, fleshy, colourless; cotyledons plano-convex in the broader way of the seed, but sometimes reversed, broadly obovate, oblong or more elongated and proportionately narrower, slightly notched at the apex by the thickening of the endosperm at the chalaza, more deeply notched at the base where the radicle and plumule lie; radicle short, straight, turbinate, obtuse, close to the hilum.

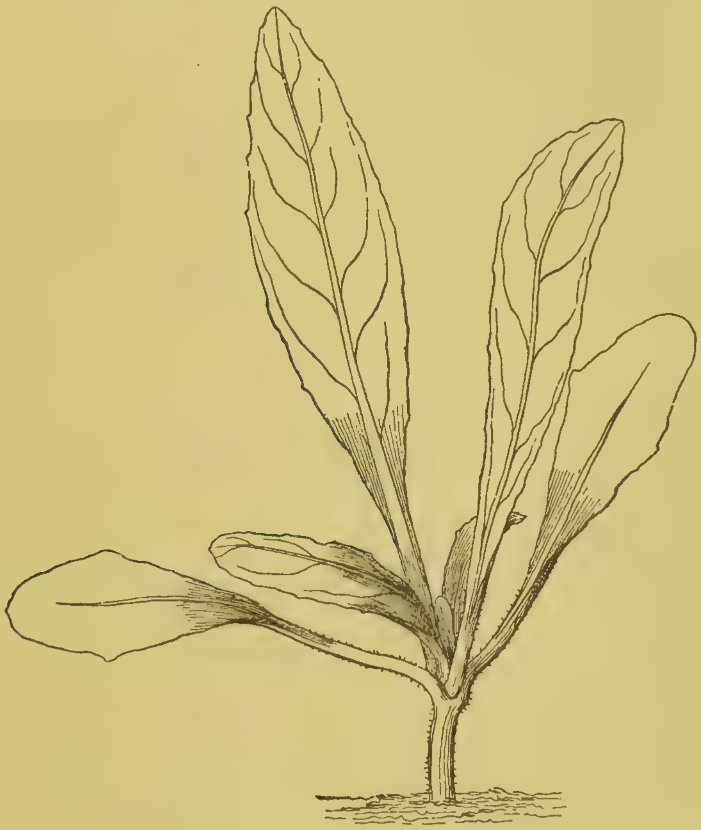

FIG. 366.—*Œnothera stricta*, × 2.

DEVELOPMENT OF COTYLEDONS.

Immediately after germination the cotyledons are oblong-oval, entire with a slightly prominent, colourless tooth at the apex of the midrib, or minutely emarginate with a sunk tooth, sessile or subsessile. Sometimes one cotyledon is entire, the other emarginate.

Six days after germination they are orbicular, slightly narrowed at the base, with a small tooth on each side above the subtruncate innovation, shortly petiolate, emarginate with a small tooth in the notch.

In ten days from germination they become ovate-oblong, or simply oblong; the lower half below the constriction has two or three small teeth on each side and is suddenly narrowed, almost truncate at the base with a pale-coloured midrib; the upper half representing the true cotyledon remains slightly elongate-orbicular with a minute tooth in the notch, and no discernible midrib in the fresh state. Petiole 1·5–2 mm.

Finally they become ovate, cuneate at the base, the innovation forming now slightly the larger part, with generally three acute or slightly incurved teeth on each side, and a ciliate margin and petiole; the upper half or true cotyledon is elongate-orbicular or rhomboid-orbicular, emarginate, with a tooth in the notch.

Seedling.

Primary root normal.

Hypocotyl erect, tapering downwards, glabrous, reddish, 9–12 mm. long.

Cotyledons ovate, obtuse, minutely emarginate and mucronate in the notch, constricted above the middle, causing the lamina to be somewhat trilobed, petiolate, alternately and ascendingly penninerved, with the lateral nerves of the upper lobe incurved and uniting at the mucro, and a strong branch entering each of the gland-tipped lateral lobes, minutely ciliate at the margin, otherwise glabrous except on the petiole; lamina 7–10 mm. long, 5–6·25 mm. wide; petiole semiterete, channelled above, minutely hairy at the margin and beneath the midrib. Apex and small teeth of lateral lobes each tipped with a glandular, colourless mucro, having a few large, more or less discoloured openings into the interior.

Stem annual, erect, terete, minutely pubescent, reddish; 1st internode 4–8 mm. long; 2nd similar.

Leaves simple, cauline, opposite in the lower part, alternate upwards, exstipulate, petiolate, alternately and ascendingly incurvinerved, finely pubescent on both surfaces, bright green above, paler beneath; petioles semiterete, channelled above, finely pubescent.

First and second pairs ovate, obtuse, obtusely or obsoletely dentate.

Ultimate leaves ovate or oval, obtuse, more or less tapering or cuneate at the base, obtusely dentate.

Œnothera tenella, *Cav., var.* quadrivulnera.

Seeds 1·5–1·75 mm. long, 1·25–1·5 mm. wide.

DEVELOPMENT OF COTYLEDONS.

The cotyledons are at first very similar to those of Œ. Lindleyana, but gradually become more cuneate at the base.

Eighteen days after germination they are obovate, emarginate with a minute tooth in the notch, and a more or less evident midrib extending to the apex, petiolate, cuneate at the base, with the upper part or true cotyledon suborbicular, and much larger than the lower foliaceous portion which is characterised by being cuneate, narrower, with two small teeth on each side, and minutely ciliate at the margin; petiole slender, semiterete, channelled above, densely pubescent.

First pair of leaves opposite, oblong or finally ovate, obtuse, mucronate, with a few small teeth on each side.

Ultimately there are two slightly different forms.

(*a*) The commoner form is obovate-cuneate, emarginate with a tooth in the notch, finely ciliate below the constriction, and having two to three small teeth there, more often slightly alternate than strictly opposite.

(*b*) The other form is obovate-oblong, considerably broader in the lower part than in the commoner form, otherwise exactly similar.

See Œnothera Romanzowii, which is said to be a variety of Œ. tenella.

Œnothera Romanzowii, *Ledeb.*

The stages of growth correspond closely to those of Œ. tenella, as does also the ultimate form of the cotyledons, the cuneate innovation tapering much more gradually into the petiole.

Œnothera purpurea, *Curt.*

Hypocotyl erect, terete, minutely pubescent, 2·5–3 cm. long, light green, tinged with red.

Cotyledons oblong-obovate, constricted above the middle, emarginate, obtuse, petiolate, with a few hairs on the petiole and base of the leaf, otherwise glabrous, light green, distinctly one-nerved.

Stem herbaceous, erect, terete, minutely pubescent; 1st internode 2–2·5 cm. long; 2nd shorter.

First leaves cauline, opposite, ovate or oblong, acute, denticulate, shortly petiolate, hoary, light green, pinnatinerved.

Œnothera bistorta, *Nutt.* (figs. 367, 368).

Seeds 1–1·25 mm. long, ·33–·5 mm. wide.

DEVELOPMENT OF COTYLEDONS.

Immediately after germination the cotyledons are oblong, obtuse, entire, sessile with a few long, scattered, glandular hairs, especially at the base. Hypocotyl with a few glandular hairs at its apex. Cotyledons often unequal, owing to their greater or less development in the seed, and one folding over the other.

Six days after germination the base has become elongated, petiole-like, and glandular-pubescent, suddenly narrowed to a short petiole or subsessile; the upper half remains rotund and glabrous except at the base and possibly a few short hairs underneath.

Eight days after germination (fig. 367) they have elongated considerably, the upper true cotyledonary part enlarging, but otherwise remaining unaltered, while the foliar basal and narrow part has become linear, entire or sometimes with a minute tooth on either side, glandular-pubescent, suddenly narrowed at the very base.

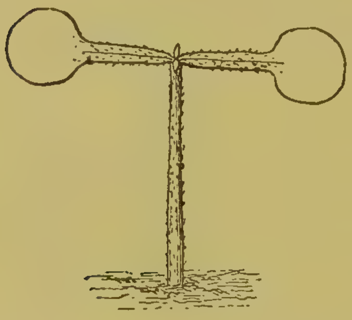
Fig. 367.—*Œnothera bistorta.*

The lower portion elongates greatly, and the ultimate stage of the cotyledons (fig. 368) is linear, tapering at the base into a petiole; upper part or true cotyledon rotund or oval, entire, glabrous, very short, without an evident midrib; lower part linear, terminating abruptly in the upper part, tapering gradually to the base, with one or two minute and distant teeth on each side, thinly hairy, greyish-green with an evident midrib sunk on the upper surface, and prominent beneath; petiole semiterete, flattened above, very thinly hairy, or at length nearly glabrous.

First eight leaves radical, alternate, linear, obtuse, tapering at the base into the petiole, thinly silky with adpressed pubescence, minutely and distantly toothed at the margin, greyish-green, more or less distinctly marked near the margin with black dots, with a very distinct, colourless midrib, flattened above and prominent beneath; petioles semiterete, flattened above, thinly hairy at the margins, colourless. (Thirty-four days after germination.)

Œnothera macrantha, *A. Gray* (fig. 369).

Primary root tapering downwards and furnished with lateral fibres, annual.

Hypocotyl undeveloped.

Cotyledons immediately after germination oval, obtuse, with a slightly prominent, apical tooth, entire, very shortly petiolate, soon becoming spathulate, with an oval, entire tip representing the true cotyledon and a linear-cuneate innovation at the base, generally with a minute or obsolete tooth on each side, distinctly but shortly petiolate, glandular-pubescent, ultimately (nineteen days after germination) (fig. 369) they become narrowly spathulate or linear, with an oval tip, sometimes narrower than the innovation, which has one to four or more obsolete teeth on each side, and gradually tapers into a long petiole-like base, with a short true petiole; the lamina is glabrous at the apex and thinly hairy elsewhere, with a distinct midrib and obscurely reticulate in a fresh state, tapering down into the petiole, dull green slightly spotted with black, 5–10 mm. long, 1·5–2 mm. wide; petiole flattened above, convex on the back, suddenly dilated at the base and forming a little cup round the plumule, somewhat pubescent.

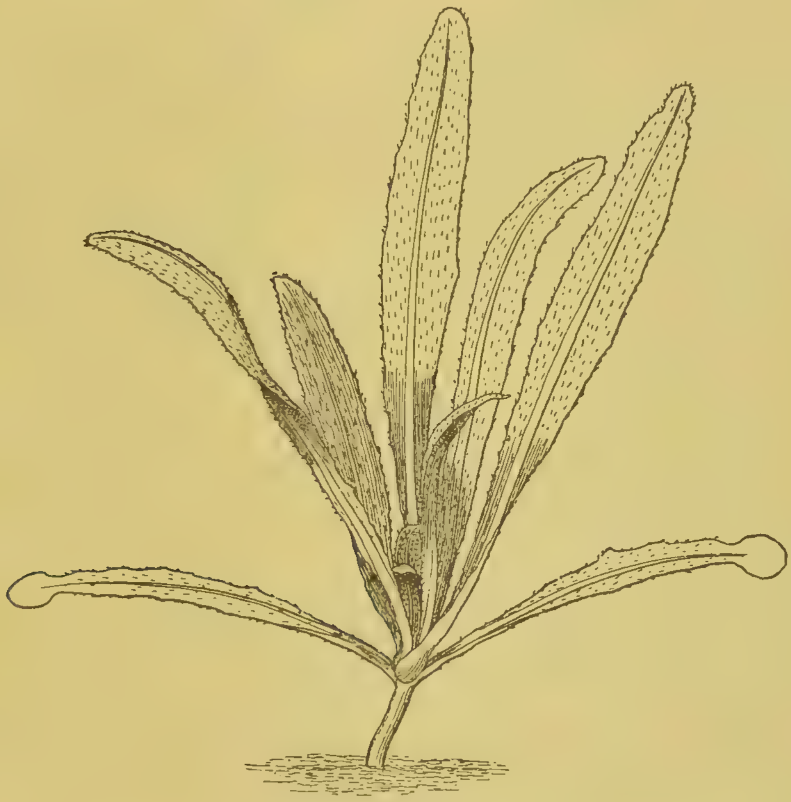

FIG. 368.—*Œnothera bistorta*,. × 3.

Stem herbaceous, annual, developed when about to flower, with many of the primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, first few petiolate, then sessile as far as the radical ones go, with difficulty discernible, alternate, ascending nerves on each side of a distinct midrib, somewhat hoary with a whitish pubescence above, more thinly pubescent beneath, dull green on both surfaces, slightly dotted with black; petioles of the first two leaves semiterete, flattened or convex above, dilated and subconnate at the base, thinly pubescent; of the third to sixth very short, and the other leaves sessile.

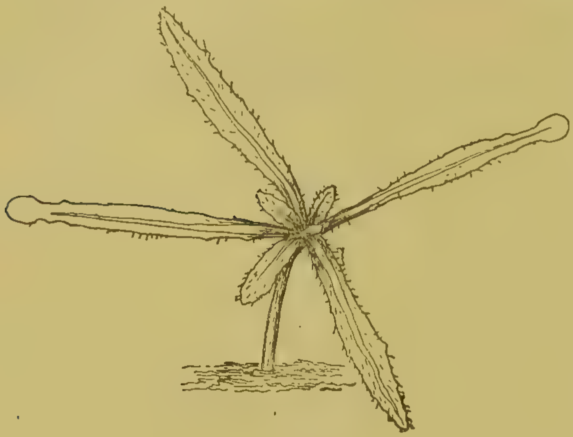

FIG. 369.
Œnothera macrantha, × 3.

Nos. 1 and 2. Linear-lanceolate, petiolate, minutely and distantly denticulate.

Nos. 3–11. Linear-oblong, obtuse, minutely and distantly denticulate, shortly petiolate, or gradually becoming subsessile, with a very distinct whitish midrib, downy.

Œnothera contorta, *Hook.*

Hypocotyl erect, terete, glabrous, 1–10 mm. long, light green or colourless.

Cotyledons at first rotund-oval, obtuse, with short petioles, but soon the petiole-like lower part develops considerably, and they assume the character of the true leaves, glabrous, indistinctly one-nerved.

Stem erect, terete, herbaceous, minutely pubescent; 1st internode 2–3 mm. long.

Leaves simple, cauline, opposite, decussate, linear, obtuse, extremely narrow, with numerous obtuse teeth, glabrous, indistinctly one-nerved.

Eucharidium grandiflorum, *Fisch. et Meyer.*

Fruit a capsule, linear-oblong, four-celled, many-seeded, dehiscing loculicidally by four valves which break away from the placental axis, covered especially in the young state with pale-coloured or white papillæ.

Seed obovoid, slightly compressed, flattened on one side and produced into a wing at each edge, and a broader wing or crest round the apical end, with the lateral wings ultimately incurved, producing a deep groove or concavity, and the crest crenate or toothed at the margin; testa subcrustaceous, deep brown, tuberculated; hilum and micropyle basal, inferior, contiguous; chalaza apical; crest and wings readily separable from the rest of the seed.

Endosperm forming a thin white film lining the interior of the seed.

Embryo comparatively large, straight, colourless, filling the entire cavity of the seed to which it conforms in general outline; cotyledons oblong, slightly emarginate from a thickening of the chalaza, auricled at the base, plano-convex, occupying the greater part of the length of the seed, and lying in its broader plane with their backs to the placenta; radicle turbinate, obtuse, several times shorter than the cotyledons, but protruded a little way beyond the auricles, and filling up the basal and narrow end of the seed.

Eucharidium concinnum, *Fisch. et Meyer.*

Seeds 1·5–2·25 mm. long, ·75–1 mm. wide.

DEVELOPMENT OF COTYLEDONS.

Cotyledons immediately after germination shortly and broadly oblong, obtuse, emarginate, with a small purple tooth in the notch, shallowly auricled at the base, sessile, minutely dotted all over the upper surface with glands. Hypocotyl minutely glandular. Primary root simple, furnished with root-hairs.

Seven days after germination they are oblong-obovate, emarginate, constricted below the middle, with the upper part or true cotyledon transversely oblong, and the lower similar, but smaller and shortly ciliate at the margin, very shortly petiolate.

Sixteen days after germination they have become broadly ovate, blunt, emarginate with the apical tooth very small and inconspicuous, shortly petiolate; upper part or true cotyledon transversely oblong, much shorter and narrower than the lower or foliaceous part, minutely and inconspicuously pubescent; lower part with three to four crenatures on each side and more conspicuously pubescent all over the upper surface than the upper part. Midrib distinct to the apex.

Twenty-five days after germination the upper part or true cotyledon has become proportionately much shorter and narrower than the lower part, and is inconspicuously and minutely pubescent; lower part very broad with three to five shallow crenatures on each side, pubescent all over the upper surface; under surface purple, or by transmitted light almost green and slightly suffused with purple; midrib distinct to the apex. Hypocotyl densely pubescent. Petioles elongated, semiterete, channelled above, densely pubescent. First two leaves opposite, oblong-ovate, obtuse, with a distinct midrib but indistinct, incurved lateral nerves, minutely glandular-pubescent all over the upper surface.

Lopezia coronata, *Andr.*

Primary root tapering downwards, with fibrous lateral rootlets.

Hypocotyl erect, subquadrangular, glabrous or with two rows of hairs, one on each side, reddish, 1·5–2·5 cm. long.

Cotyledons ovate-oblong, obtuse, rather unequal, obsoletely or shallowly trilobed, petiolate, glabrous, green, one-nerved as far as the middle, after that with no apparent venation; petioles reddish, shorter than the cotyledons, deeply furrowed on the upper face.

Stem erect, square, herbaceous; 1st and 2nd internodes about 1 mm. long.

First leaves simple, cauline, opposite, petiolate, exstipulate, ovate-oblong, acute, serrate, glabrous, green, pinnatinerved; petioles short, furrowed on the upper face.

LOASEÆ.

Benth. et Hook. *Gen. Pl.* i. 801.

Fruit and Seed.—The ovary is inferior, rarely half-superior, one- very rarely two- or three- celled, with parietal placentas, and few or numerous or indefinite anatropous ovules suspended from the apex of the cell or from parietal placentas, and arranged in one or many series. The fruit is capsular, often ribbed with the ribs straight or spirally twisted, dehiscing at the apex with three to five valves or longitudinally with three to ten openings or slits and few- or many-seeded. The seeds are generally minute, oblong or variously angled, in Mentzelia angled, flattened, or even winged; the testa is membranous or thickened and subcrustaceous, or sometimes loose and reticulate. Endosperm is absent or present in variable quantity and fleshy or very rarely horny. The embryo is straight or hooked as in Mentzelia, and linear, oblong, or terete with plano-convex foliaceous or hemispherical cotyledons, and a short or elongated radicle. When endosperm is wanting the cotyledons are fleshy. The ovule is solitary in Petalonyx, Gronovia and Cevallia, and when it has changed to a mature seed it conforms to the single cavity of the ovary. In a few species of Loasa the seeds are large, globose or oblong, with a horny albumen and minute embryo.

Seedlings.—The cotyledons, like the seeds, differ considerably. Those observed vary between roundly or broadly ovate and oval, and are generally emarginate.

Loasa prostrata, *Gill.* (fig. 370).

Hypocotyl 4–6 cm. long, erect, terete, covered with numerous hairs, some of which are much longer than the rest, and stinging, almost colourless.

Cotyledons broadly and ovately oblong, obtuse, entire, shortly petiolate, membranous, hairy with many stinging hairs, light green, five-nerved.

Stem erect, terete, herbaceous, hairy; 1st internode 5–6 mm. long.

Loasa lateritia, *Gill. et Hook.* (fig. 371).

Primary root tapering downwards, long, slender and rather sparingly furnished with lateral rootlets.

Hypocotyl erect, terete, pale green, almost colourless, hispidly pubescent, 5–7 mm. long.

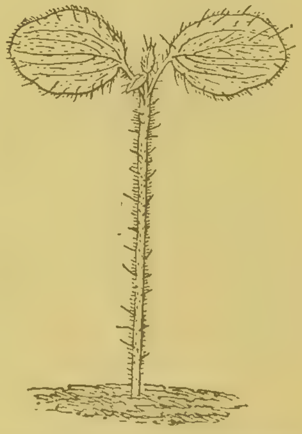

FIG. 370.—*Loasa prostrata*. Half nat. size.

Cotyledons small, rotund, emarginate, petiolate, thinly hispidly pubescent, pale green above, paler beneath, with a midrib discernible only by transmitted light; lamina 2–2·5 mm. long and wide; petiole flattened or slightly grooved above, convex below, ·5–1·5 mm. long.

Stem herbaceous, ultimately twining; primary internodes undeveloped.

Leaves simple, radical and cauline, opposite (or at least the lower ones), exstipulate, petiolate, hispidly pubescent and coarsely hairy with long, hyaline, bulbous-rooted stinging hairs, alternately and ascendingly penninerved, ultimately pinnatifid or bipinnatifid, with the ultimate segments similarly veined, and the nerves running directly into the teeth ; petioles semiterete, channelled above, glandular-pubescent and setose with stinging hairs, dilated and amplexicaul at the base.

First pair broadly ovate, obtuse, slightly dentate or entire, with a distinct midrib and one or two lateral ascending nerves on each side.

Second pair much larger, triangular, obtuse, crenate, with more numerous nerves, and glandular, mucronate teeth.

Third pair lyrately pinnatifid or pinnatisect with three segments ; lateral segments unequally ovate, obtuse, crenate-dentate ; terminal segment much larger, rhomboid-obtuse, crenate-dentate and often subtrifid ; teeth mucronate.

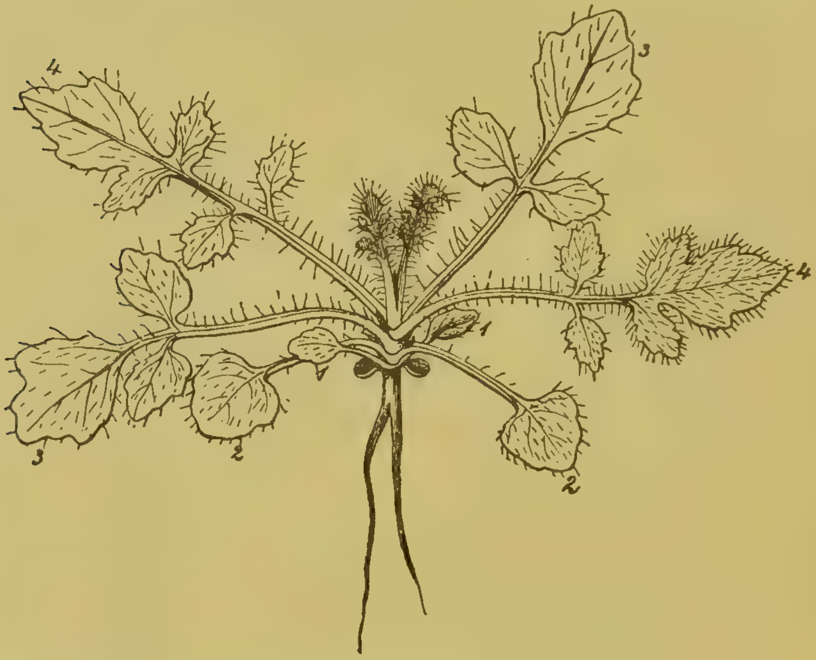

Fig. 371.—*Loasa lateritia.* Nat. size.

Fourth pair lyrately pinnatisect, with three or more, generally five, segments ; lateral segments ovate, obtuse, obtusely and mucronately dentate, more or less petiolate ; terminal segment larger, lobed or pinnatifid and mucronately dentate.

In **L. papaverifolia**, *H. B. et K.*, the hypocotyl is erect, terete, finely pubescent, and 1·5–2·5 cm. long.

The cotyledons are broadly ovate, obtuse, slightly emarginate, petiolate, and finely pubescent.

Loasa vulcanica, *Andr.*

Hypocotyl finely glandular-pubescent, variable in length according as the seeds are germinated in heat or out of doors.

Cotyledons ovate-rotund, glandular-pubescent on both surfaces, and 4–5 mm. long, 4–6 mm. wide, with a slender petiole channelled above, 1·75–7 mm. long.

Stem annual, erect, terete, densely covered with patent, glandular hairs of different lengths ; 1st internode 1–4 mm. long.

Leaves cauline and very similar to those of L. lateritia.

First pair ovate, obtuse, distantly serrate-dentate.

TURNERACEÆ.

Benth. et Hook. *Gen. Pl.* i. 806.

Fruit and Seed.—This small Order has a superior one-celled ovary and three parietal placentas on which the numerous ascending anatropous ovules are arranged in a double series. The fruit is capsular, many-seeded, and dehisces loculicidally throughout its length by three valves. The seeds are oblong-cylindrical, sometimes with a prominent raphe and chalaza, reticulate or covered with small depressed areas and slightly curved. They are furnished with a membranous aril along the same side as the raphe. The endosperm is copious and fleshy. The embryo is straight, axile, and narrow, with plano-convex cotyledons and an elongated radicle.

Seedlings.—The only seedling of this Order coming under my notice is Turnera elegans (fig. 372). The cotyledons are ovate, petiolate, with a distinct midrib and two faint lateral nerves. The first two leaves are opposite, oblong-lanceolate, incise-serrate, while succeeding ones are alternate. A peculiar feature of the venation is that the primary veins run into the sinuses, not the teeth of the leaves. In some species of Turnera and Wormskioldia the ultimate leaves are pinnatifid.

Turnera elegans, *Otto* (fig. 372).

Hypocotyl erect, terete, pubescent or hairy with upcurved and incurved hairs, pale green, 1–1·5 cm. above soil.

Cotyledons ovate, obtuse, petiolate, glabrous except the petioles with a distinct midrib and two slender, rather indistinct lateral nerves, light green; lamina 6·5–8 mm. long, 4–5 mm. wide; petiole slightly grooved above, hairy, 3 mm. long.

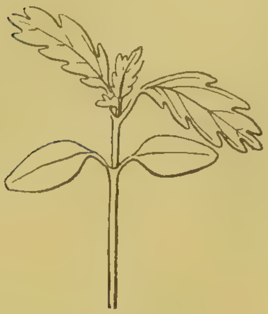

FIG. 372.
Turnera elegans.
Nat. size.

Stem erect, terete, hairy with patent and ascending incurved hairs, pale green; 1st internode 3–8 mm. long.

Leaves simple, cauline, alternate (1st and 2nd opposite), exstipulate, petiolate, thinly hairy on both sides, alternately penninerved with the nerves running into the sinus of the serratures, light green; petioles shallowly grooved above, hairy, pale green, with usually two tooth-like glands on the margins above the middle.

Nos. 1 and 2. Opposite, oblong-lanceolate, incise-serrate, with obtuse or subacute serratures.

Nos. 3 and 4. Alternate, lanceolate-oblong, incise-serrate, with obtuse serratures.

PASSIFLOREÆ.

Benth. et Hook. *Gen. Pl.* i. 807.

Fruit and Seed.—The ovary is syncarpous, quite free from the receptacle, and one-celled with three to five parietal placentas denoting as many carpels. The ovules are numerous, rarely few, pendulous, anatropous with a superior micropyle, and ventral raphe, and arranged in one to numerous series on the placentas. The funicle sometimes attains considerable length, and usually becomes widened or dilated at the apex forming a cup-shaped aril. The fruit is baccate or capsular, indehiscent or dehiscing loculicidally, and usually containing a large number of seeds. The latter are ovate or oval, much compressed, rarely oblong, or much thickened, covered with a fleshy or pulpy aril. The testa is leathery or often greatly thickened, crustaceous, black and pitted or indented so deeply in some cases that it forms small pointed processes projecting into the endosperm. The latter is fleshy and scanty or copious. The embryo is of large size, embedded in the endosperm, straight with broad foliaceous cotyledons, and an elongated radicle.

Basananthe is exceptional in having only three ovules in the ovary. In some species of Carica the ovary is five-celled by the development of spurious septa. A curious case occurs in Ceratiosicyos where the stipitate capsule is elongated, terete, membranous and greatly resembling a siliqua. Passiflora, Tacsonia and several other genera have also a stipitate ovary and fruit resembling that of the Capparideæ, where the capsule is also siliquiform in a number of genera.

A good type of the Order is furnished by Passiflora macrocarpa (fig. 373) which has a greatly thickened testa slightly indented and pushing blunt points into the endosperm. There is a groove in the edges of the seed and the raphe passes along it on one edge.

The cotyledons are broadly oblong-oval, slightly inclined to be cordate at the base. Tacsonia ignea (fig. 376) differs chiefly in the relatively smaller size of the embryo, the absence of a groove on the edges of the seed, and in the testa being rather deeply depressed in places but hardly indented. The cotyledons are trinerved. The seeds of Tacsonia tubiflora are obovate, rather thickened, not grooved at the edges, but deeply indented internally, and running into the endosperm. In other respects it agrees with the two former species.

Seedlings.—The prevailing types of cotyledons belonging to different genera and species of the Passifloreæ vary from oblong to oval, and are foliaceous, entire, or slightly emarginate, three- or faintly five-nerved, reticulate and shortly petiolate. A fairly representative type of the Order is that of Passiflora cærulea (fig. 375). The first eight leaves are entire and vary from broadly ovate to the eighth which is lanceolate. From the ninth to the eleventh inclusive they are palmately tri-nerved and -partite. The ultimate leaves are five- to seven-lobed with linear lobes. In Passiflora Leschenaultii the third, in Tacsonia ignea the second, and in T. Van Volxemii the first leaf is already trilobed. P. macrocarpa (fig. 374) has broadly or roundly oblong much reticulated cotyledons. All the leaves are entire and oblong-ovate from first to last. The cotyledons of P. Leschenaultii are inclined to be oblong-ovate. The first leaf is transversely oval; the second roundly ovate; the next three shortly trifid and three- or faintly five-nerved.

A slight modification from the above types is met with in P. maliformis which has broadly oblong, emarginate cotyledons. Its first three leaves are lanceolate and acuminate with a shallowly cordate base. In P. edulis the cotyledons are oval, and the first three leaves oblong-elliptic, and obtusely acuminate.

The oval cotyledons of T. Van Volxemii (fig. 378) are trinerved, but the lateral nerves give off each a strong branch. The first leaf is oblong, shortly trifid, and is followed by five others which are trinerved and tri-lobed or -partite, with narrowly oblong, or lanceolate, finely serrulate lobes. The cotyledons of Carica cundinamarcensis (fig. 380), and those of C. Papaya maxima differ but slightly from the type in being broadly oblong, and cuneate at the base. The first two leaves of the former are oblong-cordate, shallowly and coarsely toothed; these are succeeded by six others which show a few large teeth as if they were inclined to become pinnatifid. The first leaf of C. Papaya maxima is small, lanceolate, and entire.

The most remarkable variation from the type occurs in Modecca trilobata (fig. 379). The cotyledons are unusually large, broadly ovate and obtuse, with a wide sinus or indentation near the apex on one side, trinerved and copiously reticulate. The first leaf is ovate, subcordate at the base, distantly and irregularly toothed, and strongly acuminate. The second and third ones are deeply trilobed with ovate or lanceolate, acuminate, entire lobes.

Passiflora Leschenaultii, *DC.*

Hypocotyl glabrous, about 1 cm. long.

Cotyledons oblong-ovate, obtuse, subemarginate; limb 9 mm. long, 6 mm. wide; petiole 3 mm. long.

Stem flexuose, suffrutescent, striate or somewhat furrowed, pubescent, green; 1st internode 3 mm. long; 2nd 3·5 mm.; 3rd 4·5 mm.; 4th 5·5 mm.; 5th 4·5 mm.

Leaves.—No. 1. Transversely oval, cuspidate, three- to five-nerved, subciliate at the margins, and pubescent on the nerves on both surfaces, 1·75 cm. long, 1·1 cm. wide; petiole slender, subterete, subchannelled on the upper side, pubescent, 1·5 cm. long.

No. 2. Rotund-ovate, acute, trinerved; lamina 2 cm. long, 1·75 cm. wide.

No. 3. Rotund-ovate, subtrifid, palmately trinerved; lateral lobes small, triangular, cuspidate; middle lobe large, triangular, acute.

Nos. 4 and 5. Similar but proportionately broader and more decidedly palmate.

Passiflora macrocarpa, *Mast.* (fig. 373).

Fruit oblong, obtuse at both ends, stipitate, glabrous, one-celled, many-seeded, baccate or fleshy when mature, large and thick, indehiscent.

Seeds obovate, much compressed, bidentate at the base, tridentate at the apex, margins irregularly crenate, with the testa produced all round into a double wing, convex in the middle, and pitted with round or angular depressions, arillate; chalaza basal, forming a turbinate, yellow thickening, hidden by the wings or produced edges of the testa, and in close contact with the endosperm; raphe passing round from near the emargination of the base, and beneath or between the wings of the testa to the chalaza lying beneath the middle tooth at the basal end; micropyle superior; funicles stout, elongated, produced into a cup-shaped or subcylindrical aril, enclosing the seed but open at the upper end; hilum a little to one side of the emarginate base.

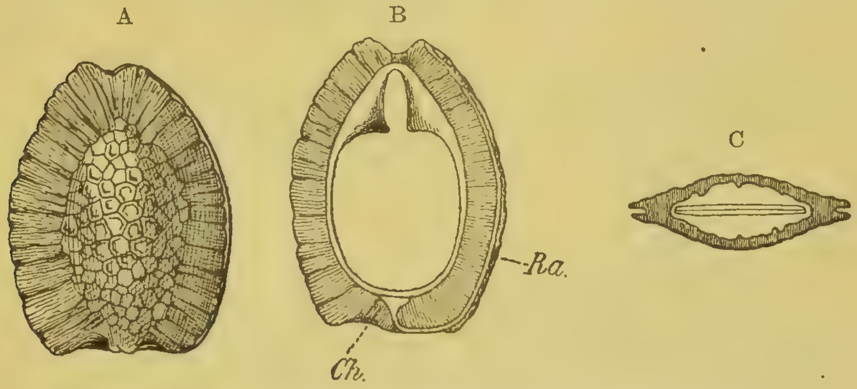

FIG. 373.—*Passiflora macrocarpa*. A, seed. B, longitudinal section of seed *Ch*, chalaza; *Ra*, raphe. C, transverse section of seed. All × 3.

Endosperm copious, fleshy, pitted by the indentations of the testa, and surrounding the embryo.

Embryo straight, large, colourless, nearly equalling the endosperm in length; cotyledons oblong-oval, obtuse, entire, slightly cordate at the base, alternately and ascendingly penninerved; radicle cylindrical, obtuse, slightly thinner at the base of the cotyledons, and much shorter.

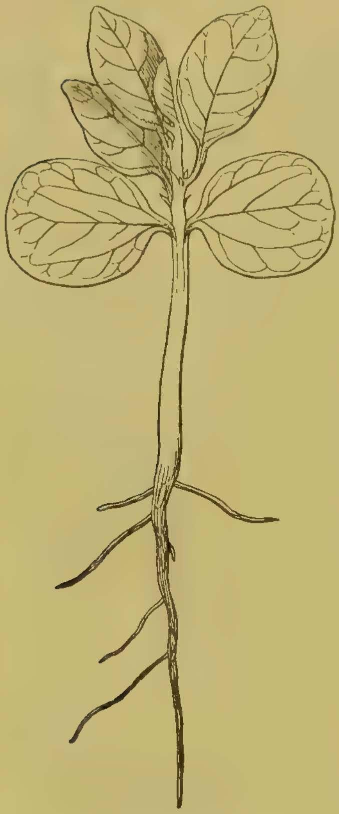

Fig. 374.
Passiflora macrocarpa.
Nat. size.

Seedling (fig. 374).

Hypocotyl stout, erect, terete, but obtusely quadrangular beneath the cotyledons, glabrous, pale green, tapering upwards, 2·3–2·7 cm. above the soil.

Cotyledons foliaceous, oblong-rotund, entire, very obtuse and rounded at the apex, shortly petiolate, three- or slightly five-nerved at the very base, reticulate, glabrous, shining on both surfaces, light green above, paler beneath; lamina 1·4–1·6 cm. long, 1·3–1·35 cm. wide; petiole flattened above, convex on the back, broadest at the base of the lamina, 2 mm. long, with their edges decurrent on the hypocotyl.

Stem erect, slightly angled, pale green, glabrous, ultimately climbing by means of cirrhi from the axils of the petioles, acutely quadrangular or winged; 1st internode 2·25–3·5 mm. long; 2nd 2·5–4 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, alternately incurvinerved, subreticulate, glabrous, light or bright shining green above, paler beneath; petioles short, flattened above or shallowly grooved on each side of a raised midrib, obtusely carinate beneath; stipules small, subulate, acute, entire or slightly serrate at the apex, pale green, glabrous, seated at the very base of the petiole or close to the stem.

Nos. 1 and 2. Ovate, obtuse, minutely apiculate, minutely and distantly serrulate.

No. 3. Subelliptic, otherwise similar to the first two.

Passiflora cærulea, *L.* (fig. 375).

Primary root long, tapering, abundantly furnished with adventitious rootlets.

Hypocotyl erect, suffrutescent, terete, longitudinally ribbed with elevated tuberculated lines, reddish, 3 to 4 cm. long.

Cotyledons foliaceous, petiolate, glabrous; lamina oblong-oval, obtuse, trinerved, 13·5 mm. long, 8·5 mm. wide; petiole channelled above, 7·5 mm. long.

Stem erect, terete, ultimately climbing, suffrutescent, marked with lines of small tubercular bodies, glabrous, green, becoming stained with red; 1st internode 1·6 cm. long; 2nd 9 mm.; 3rd 9 mm.; 4th 1 cm.; 5th 1·5 cm.; 6th 2·5 cm.; 7th 2·25 cm.; 8th 3·35 cm.; 9th 5·85 cm.; 10th 6·4 cm.

Leaves simple, cauline, alternate, stipulate, petiolate, glabrous, dark green above, pale beneath, red or violet at the margin; petioles subterete, tapering upwards, pale green, suffused with red, often bearing capitate, stalked glands on the upper side which secrete a viscid, transparent liquid; stipules on the lower part of the stem, subulate, acute, attenuate, reddish, on the upper part of the stem, half cordate, acuminate, foliaceous, green, reticulate with a reddish margin.

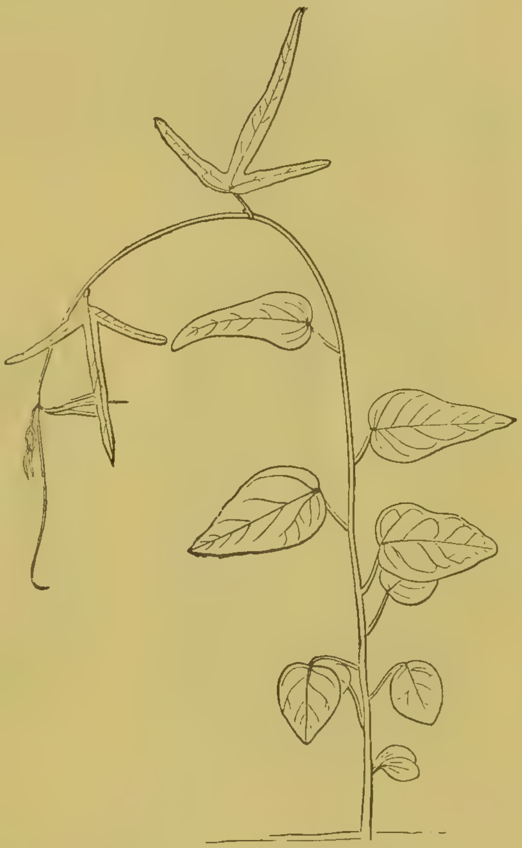

FIG. 375.—*Passiflora cærulea.* One-third nat. size.

Nos. 1 and 2. Small, broadly ovate, obtuse.

Nos. 3 to 5. Ovate, obtuse, mucronate.

Nos. 6 and 7. Ovate, attenuate, obtuse, mucronate, serrulate at the base.

No. 8. Lanceolate, attenuate, obtuse, mucronate or rather apiculate, serrulate at the very base, with ascending subincurved nerves as have all those below it.

Nos. 9–11. Palmately tri-partite and -nerved, or five-nerved at the base; lobes linear, attenuate, obtuse, apiculate, reticulate.

Cirrhous tendrils equivalent to branches are given off in the axils of the eleventh, twelfth and succeeding leaves.

Tacsonia ignea, *Hort.* (fig. 376).

Fruit globose or oblong, baccate, stipitate, one-celled with three parietal placentas, many-seeded, indehiscent.

Seed obovate, much compressed laterally, tridentate at the apex, blunt or emarginate at the base, enclosed in a cup-shaped funicular aril; testa thick, crustaceous, glabrous, black, deeply pitted on both sides with the impressions so deep as to affect the aril; chalaza apical and passing through the testa, where it abuts against the endosperm in a dull yellow conical mass; raphe ventral passing along one edge of the seed from the hilum in the basal notch to the chalaza seated in the middle tooth at the apex of the seed. Seed 4·25–4·75 mm. long; 2·75–3 mm. wide; 1·75–2 mm. thick.

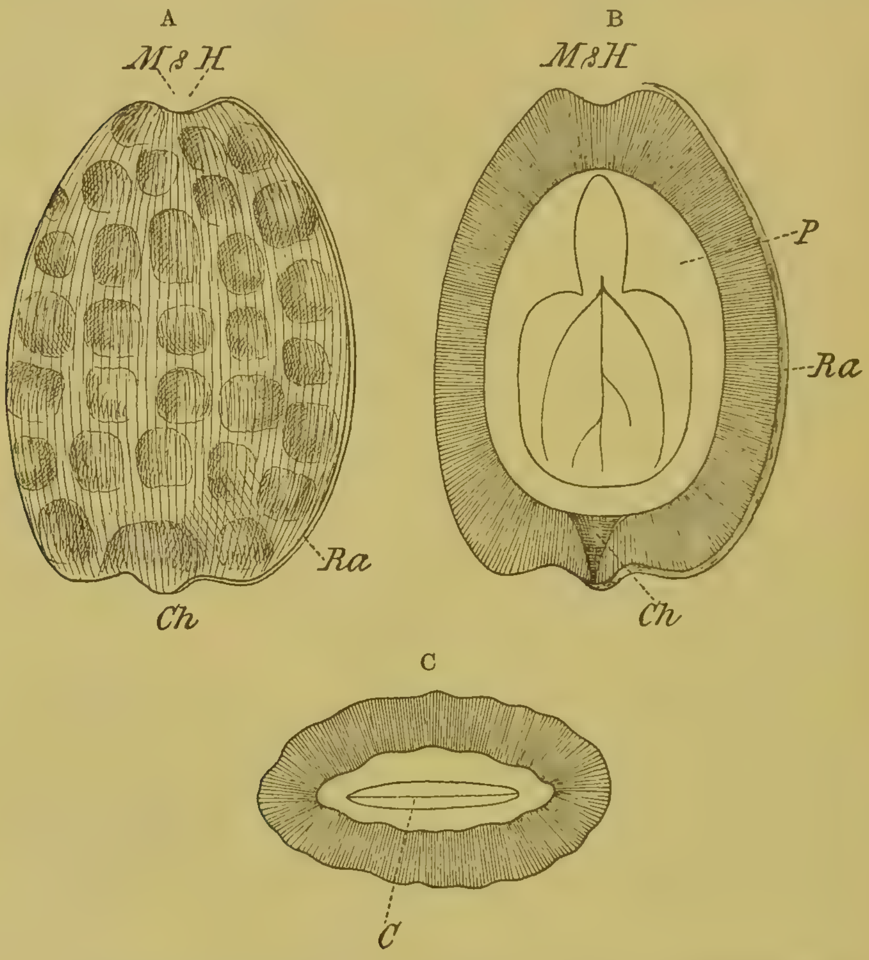

Fig. 376.—*Tacsonia ignea*, × 12. A, seed. B, longitudinal section of seed. C, transverse section of seed: *M & H*, position of micropyle and hilum; *Ch*, chalaza; *Ra*, raphe; *P*, endosperm; *C*, cotyledons.

Endosperm rather copious, fleshy, white, brittle, embedding the embryo.

Embryo straight, flat, nearly equal in length to the endosperm, colourless; cotyledons broadly oblong-oval, entire, and rounded at both ends, closely applied face to face, embedded in the endosperm, and a little narrower than it, about twice as long as the radicle; radicle oblong-elliptical, suddenly pointed, embedded in the endosperm close to the micropyle.

Seedling (fig. 377).

Hypocotyl subwoody, erect, terete, glabrous, pale green, 1–1·5 cm. long, 1 mm. thick.

Cotyledons petiolate, rotund-oval, obtuse, trinerved, pale green, glabrous; lamina 9 mm. long, 6 mm. wide; petiole channelled above, 2·5 mm. long.

Stem soft and succulent at first, erect, terete, glabrous or almost so, pale green; first three internodes each about 1 cm. long.

Leaves simple, cauline, alternate, stipulate, petiolate.

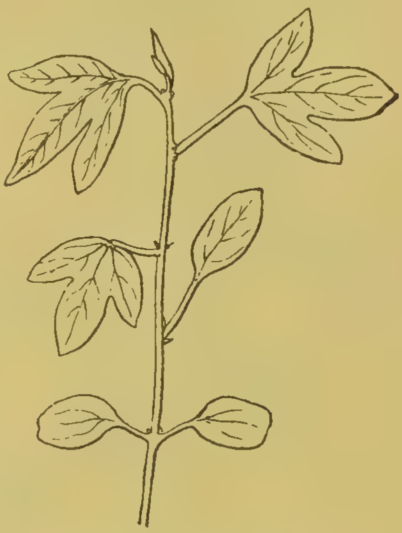
Fig. 377.—*Tacsonia ignea.* Nat. size.

No. 1. Oval, cuspidately acute, serrulate, with gland-tipped serratures, obscurely penninerved; petiole subterete, faintly channelled above, glabrous; stipules free, subulate, acute, small.

No. 2. Palmately tri-lobed and -nerved, finely serrulate at the margin; lateral lobes oblong, apiculate; terminal lobe oblong-oval, obtuse, apiculate.

Nos. 3 and 4. With longer, more pointed and apiculate, lateral lobes; terminal lobe oblong, longer and more acuminate than that of leaf No. 2.

Tacsonia Van Volxemii, *Hook. f.* (fig. 378).

Primary root suddenly tapering to a fine point and furnished with numerous strong lateral fibres.

Hypocotyl erect, subflexuose, terete, suffrutescent, glabrous, pale green suffused with red, 4·7 cm. long.

Cotyledons foliaceous, petiolate, glabrous, entire; lamina oval, obtuse, trinerved, deep green, shining, 11 mm. long, 7 mm. wide; petiole subchannelled above, 6 mm. long.

Stem woody, erect at first and subflexuose, somewhat angular, glabrous, pale green; 1st internode 7·5 mm. long; 2nd 5·5 mm. 3rd 9 mm.; 4th 1·5 cm.; 5th 1·3 cm.

Leaves simple, cauline, alternate, stipulate, petiolate, glabrous lobed and glandular-serrulate; petiole subterete, channelled above glandular towards the top, and glabrous, pale green or tinged with red on the upper side; stipules lanceolate or subulate, subacute glabrous, pale green, free.

No. 1. Oblong, trinerved, shortly trifid; lateral lobes ovate, mucronate; middle lobe ovate, elongate, mucronate.

No. 2. Tri-partite and -nerved; lobes lanceolate, apiculate; middle one slightly longest.

No. 3. Tri-partite; lateral lobes oblong; middle lobe lanceolate-elliptic.

Nos. 4–7. Tri-partite and -nerved; lobes linear-oblong, obtuse; middle one longest.

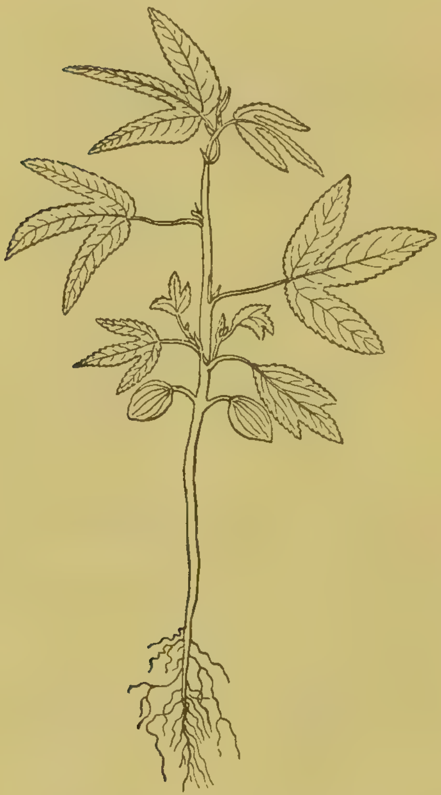

Fig. 378.—*Tacsonia Van Volxemii.* Half nat. size.

Modecca trilobata, *Roxb.* (fig. 379).

Hypocotyl erect, terete, glabrous, stout, pale green, shining, 4–6 cm. above the soil.

Cotyledons very large, foliaceous, broadly ovate, obtuse, subcordate at the base, much cut away near the apex on one side, petiolate, glabrous, bright green and shining above, pale or subglaucous beneath and shining, with five ascending and incurved nerves arising in the top of the petiole; lamina 3·9 cm. long, about 3·2 cm. wide in the middle, in average seedlings; petiole stout, channelled above, convex on the back, about 1·2 cm. long.

Stem erect at first, ultimately twining, terete or slightly and obtusely angled, especially about the nodes, glabrous, pale green, shining; 1st internode 1·27 cm. long; 2nd 8·5 mm.

Leaves simple, more or less lobed, cauline, alternate, stipulate, petiolate, glabrous, shining green above, subglaucous and shining beneath, five-nerved from the base, more or less strongly and alternately nerved upwards, reticulate, biglandular at the base of the lamina; petiole subterete, narrowly and shallowly grooved on the upper side, pale green, shining, tapering upwards from a stoutish base; stipules small, subreniform, lacerated at the margin, glabrous, transparent or hyaline except at the very base, seated on a short pedestal. The glands are always on two small basal auricles, and together form a small arch over the top of the petiole.

No. 1. Ovate-cordate, strongly acuminate, irregularly and coarsely dentate below the middle, often trilobed, five-nerved from the base, and alternately nerved upwards, reticulate. The two basal nerves are always slender, while those next are always strong and like those above them incurved, giving off branches only to the teeth and to the higher nerves.

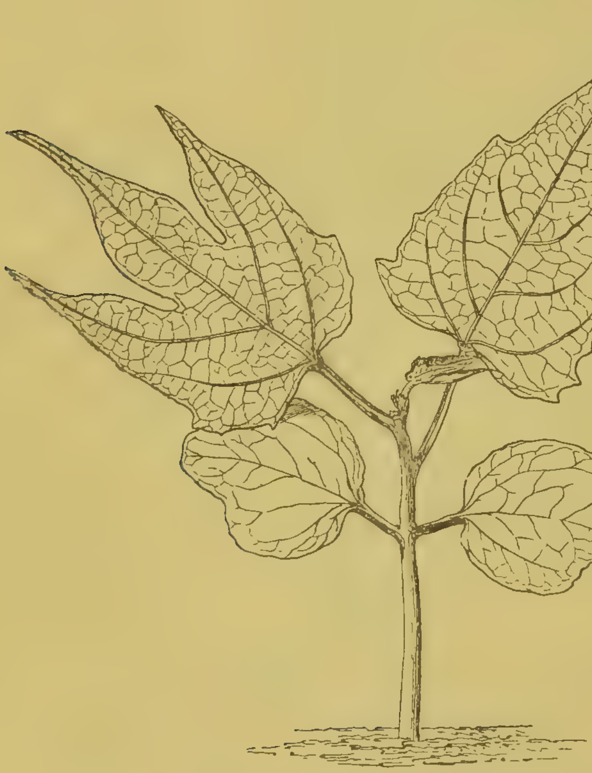

FIG. 379.—*Modecca trilobata.* Half nat. size.

Nos. 2 and 3. Deeply trilobed, subcordate and five-nerved at the base; lowest pair of nerves slender; second pair strong, ascending towards the margin of the leaf and partly into the base of the lateral lobes, giving off lateral branches which form a series of submarginal arches continuous with the lowest pair of nerves, and continuing in the same manner to the apex of the strongly acuminate lateral lobes of the leaf. The third pair of nerves, originating below the middle of the leaf, are subopposite, strong, and run longitudinally to the very apex of the lateral lobes, giving off branches that curve and unite at their apex; midrib running to the apex of the middle lobe and similarly branching.

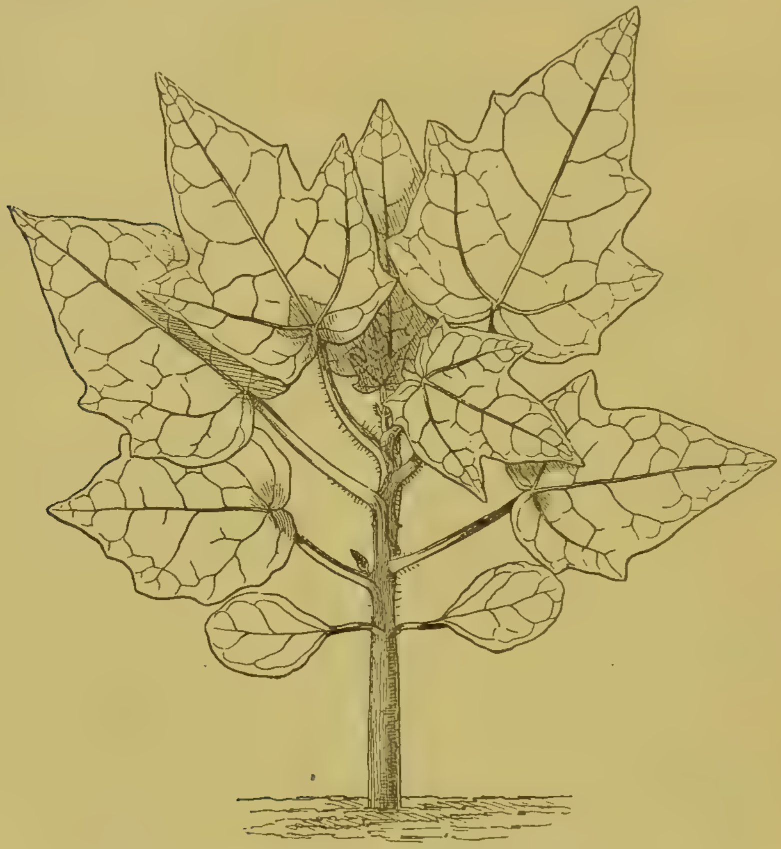

Fig. 380.—*Carica cundinamarcensis.* Half nat. size.

Carica cundinamarcensis, *Lind.* (fig. 380).

Hypocotyl stout, erect, terete, fleshy, tapering upwards, glabrous, pale green, becoming brown, 4·0–4·7 cm. long, or sometimes more.

Cotyledons broadly oblong, obtuse, entire, subcuneate at the base, petiolate, trinerved at the base, alternately nerved upwards with the nerves uniting and forming an intramarginal wavy line, reticulate, at least when old, not very persistent, glabrous; lamina 2·5–2·8 cm. long, 1·6–1·8 cm. wide; petiole rather slender, channelled above, 1·0–1·2 cm. long.

Stem erect, stout, fleshy, flexuose in the young state, and more or less angled by the decurrent bases of the leaves, slightly hairy just beneath the petiole, brownish-green, ultimately shrubby, fleshy; 1st internode 8 mm. long; 2nd 4 mm; 3rd 6 mm; 4th 3·5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, three- to seven-nerved at the base, alternately nerved upwards, reticulate, hairy on the nerves beneath, and subglandular-ciliate, deep shining green above, glaucous or whitish beneath, with numerous small glands at the junction of lamina and petiole on the upper side, and a few small scattered ones on the midrib and principal nerves; petioles tapering upwards from a stout base, subterete, channelled on the upper side, glabrous except on the under side especially at the base; stipules small, tooth-like, tipped with a pale-coloured gland, seated on the somewhat decurrent base of the petiole.

No. 1. Oblong-cordate, obtuse, five-nerved at the base, with about two sinuate or repand obtuse teeth on each side.

No. 2. Similar, but angled or bilobulate on each side below the middle.

No. 3. Cordate-ovate, with one to two teeth on each side towards the base.

Nos. 4 and 5. Cordate, elongate, with two to three repand teeth on each side.

Nos. 6–8. Palmate, elongate, five-nerved at the base, three- or slightly five-lobed; basal lobes small, triangular, or tooth-like; middle lobes larger, triangular, subacute; terminal one much the largest, triangular-ovate, subacute, entire or slightly toothed.

CUCURBITACEÆ.

Benth. et Hook. *Gen. Pl.* i. 816.

Fruit and Seed.—The ovary, consisting for the most part of three carpels, is inferior, in a few cases free at the apex. It is three-, rarely one- or two-celled, or spuriously four- to five-celled. The species belonging to the tribe Elaterieæ are altogether abnormal; some have a one- or two-celled ovary, others are many-celled by the development of spurious septa between the seeds. Normally the placentas are parietal, fleshy, very often confluent in the axis of the ovary, and again reflexed towards the circumference. The ovules are pendulous, horizontal, or ascending and anatropous; and in ovaries consisting of one carpel they vary from one to two and are inserted at the base or suspended from the apex of the cavity. To be basal and erect is however unusual. In ovaries of three carpels and three cells, they are inserted on the sides of the placentas nearest the peripheral walls.

The fruit is in most cases baccate, and fleshy or cortical, and botanically termed a *pepo*; very often it is one-celled by the destruction of the septa which become pulpy; hence the seeds are nearly always embedded in pulp. It is mostly indehiscent, rarely opening by valves or by an operculum, and many-seeded. In Elaterium and its allies the fruit separates from its peduncle, leaving an opening through which the pulp and seeds are ejected with some force by the elastic contraction of the walls. The seeds, like the ovules, vary in direction and are very often flattened as in the Passifloreæ. The testa is membranous, cartilaginous or crustaceous, granular, tuberculate, or smooth, sometimes covered with a watery epidermis, and toothed or lobed at the edges. The tegmen also varies in thickness and other characters. Endosperm is wanting; and the embryo therefore conforms to the cavity of the seed. The cotyledons are foliaceous and flattened, or plano-convex according to the thickness of the seed; and the radicle is comparatively short.

Besides the anomalous or unusual forms mentioned above, Sechium edule is remarkable for its large, obovoid, fleshy, one-celled, one-seeded fruit. The seed is also large, subglobose, with a woody testa, and conforms to the interior of the indehiscent fruit. The embryo is very large and germinates in the fruit before the latter drops from the plant. The ovules and seeds of Hodgsonia heteroclita are connate in pairs, of which one is large and fertile, and the other small and empty.

A type of an obovoid and rather thickened seed is furnished by Bryonia dioica. It is surrounded by a slightly raised margin and is somewhat compressed laterally with a pale, crustaceous testa. The cotyledons are plano-convex, but otherwise characteristic of the Order. The average size of the seeds is 4·4 mm. long by 3·08 mm. wide and 2·2 mm. thick. The seeds of B. laciniosa (fig. 389) are somewhat larger, being 5 mm. long by 3 mm. wide. They are surrounded at the edges by a narrow ridge, and have a large mass of cortex projecting from each side and corresponding in position to the back of the cotyledons which are rather more flattened here than in the case of Bryonia dioica. The embryo as a whole is amygdaloid.

The seeds of Trichosanthes Anguina are very variable in shape, even in the same fruit, being oblong, oval, or suborbicular, much flattened laterally and irregularly jagged or crenate at the edges, presenting a gnawed appearance. The embryo conforms to the shape and size of the seed, and even when in the latter sometimes shows the effect of the indentations. This may be compared with the behaviour of the testa in Passiflora, where however the indentations affect the endosperm only. The fruit is very remarkable, being snake-like, more or less twisted, two to three feet long, green, striped with grey and scarlet when mature.

Seedlings.—Owing to the relatively uniform character of the seeds of this Order and the absence of endosperm, there is a very moderate amount of variation in the shape and appearance of the cotyledons. The seeds on the whole are relatively large, sometimes very large; and throughout the Order, so far as observed, the seedlings are correspondingly large and vigorous from the earliest stages of germination onwards. Generally speaking, the largest cotyledons come from the largest seeds; but there are cases where the cotyledons of some species greatly exceed in size those of another species of the same genus, even although there is comparatively little difference in the size of the seeds. This arises in consequence of the growth after germination being more vigorous in some than in others. The shape of the seed would have some bearing upon the ultimate shape of the cotyledons, but modifications occur where these become much widened near the apex; and although the cotyledons as far as observed are always entire in the seed, they ultimately become more or less emarginate in some species by growth after germination. The simplest type appears to be that of Momordica involucrata, the seedlings of which have oblong-spathulate cotyledons, slightly connate at the base, of moderate size and sessile. The first two leaves are roundly cordate, opposite and five-nerved. Succeeding ones are three- to five-lobed and alternate. M.

muricata (fig. 384) differs in having somewhat larger cotyledons and two pairs of opposite leaves, the first pair being obsoletely trilobed at the apex and seven- to nine-nerved. Trichosanthes palmata (fig. 382), T. Anguina, and Cucumis utilissimus have obovate-spathulate, three- to five-nerved cotyledons of much greater size than those of Momordica. The first named has the first leaf reniform and inserted close to the cotyledons owing to the non-elongation of the first internode. The primary leaves of Trichosanthes Anguina are cordate and also alternate, but all the internodes are elongated. A very remarkable instance of variability occurs in this species, for although the usual type is that just given, seedlings occur in which the two first leaves are opposite, and in rare cases there are three cotyledons followed by three leaves also in a whorl.

A second type is that in which the cotyledons are oblong or obovate-oblong, and narrowed at the base into short, more or less channelled petioles. They are also three- to five-nerved, although the intermediate pairs of nerves are not strictly basal.

Cucumis sativus (fig. 386) is an instance with entire cotyledons. The first leaf is cordate, incipiently lobed, and is inserted on the axis close to the cotyledons, a circumstance of very frequent occurrence, as for instance in Trichosanthes palmata mentioned above and Acanthosicyos horrida (fig. 383), Citrullus Colocynthis, Cephalandra palmata (fig. 388), Bryonia laciniosa (fig. 390) and Cionandra. In all the last five the cotyledons are large and more or less deeply emarginate. The primary leaves of most of them are very characteristic of the Order and show a greater or less amount of evolution. A good instance is that of Citrullus Colocynthis, the first leaf of which is rotund, truncate at the base, and obscurely crenate; the second is oblong-cordate, five-nerved and shallowly five-lobed, followed by others that are more deeply and sharply divided. The first leaf of Cephalandra palmata is cordate; the second and third palmately three- to five-nerved and -lobed. The first six leaves of Bryonia laciniosa are five-nerved and deeply tripartite, the divisions being narrow from the third leaf onwards. The most striking case occurring in this group, or indeed in the whole Order, is that of Acanthosicyos horrida which bears organs that are morphologically leaves but are functionally useless as such. The first leaf is small, linear, entire, concave and carinate. From the second to the fifth inclusive they are gradually smaller and subtended by a pair of spines, but otherwise similar to the first. This, the only species of the genus, is a native of the dry sandy deserts of Angola and Dammara Land; and the reduction in size or almost entire abortion of the leaves is the expression of the adaptation of the plant to its environment.

Besides the above types a few others may be mentioned which differ so much from the leading ones and from one another as far as the cotyledons are concerned that they may be regarded at any rate for the present as exceptional. The cotyledons of Bryonia dioica (fig. 391) are suborbicular, entire, suddenly cuneate at the base, with slender, considerably elongated petioles. They are small compared with those of B. laciniosa, and altogether different in shape. The elongation of the petioles would appear to be necessary owing to the hypocotyl being almost suppressed or scarcely rising above ground. Thladiantha dubia (fig. 385) has a relatively short hypocotyl, suborbicular, broadly and shallowly emarginate cotyledons, with comparatively long petioles, all of which are rather thickly strewn with stiffish hairs.

An extraordinary instance of another kind occurs in Megarrhiza californica, the hypocotyl of which is short, subterranean, and together with the upper portion of the root becomes developed into an enormously thickened and fleshy tuberous structure. The cotyledons are large, fleshy, plano-convex, and never leave the large, oblong, tumid seed although they are carried two or three inches above ground by the petioles. The latter appear further to be connate into a cylindrical tubular body tapering upwards, but they are really separable. The plumule proceeds from a slit between the petioles close to the base of the latter at the level of the ground or below it. The first three or four leaves are reduced to small scales. All this growth preliminary to the development of normally expanded leaves is produced at the expense of the fleshy cotyledons. This behaviour shows that the plant is adapted to germinate and rise through a considerable depth of superincumbent sand, or other material. The fleshy cotyledons and the large subterranean tuberous root would also show an adaptation to a dry climate or soil.

Trichosanthes Anguina, *L.*

Root fibrous.

Hypocotyl herbaceous, 5–8 cm. long, 3–4 mm. thick, twisted, suberect, multiangular, slightly pubescent, pale green.

Cotyledons opposite, sometimes but rarely 1–3 and whorled (probably liable to still further modification), sessile, oblong-spathulate, obtuse, often emarginate, with entire, undulated and recurved margins, obscurely trinerved above, outer nerves showing veins running towards the margin if seen from below, thick, scabrous, rather persistent.

Stem ridged, suberect; 1st internode 3–4 cm. long, 2 mm. thick, slightly pubescent and scabrous; 2nd 5–7 cm. long, 1·5 mm. thick, with swollen buds in the axils of the first leaves and more hispid; in some the first two internodes are very short and stout, while the third elongates considerably.

Leaves usually alternate, but often opposite or even whorled, long-petioled, 7–12 cm. long, 4–7 cm. wide (the alternate ones being the largest, cordate-ovate, with deep base and acute or acuminate apex, sinuate-dentate, or doubly dentate, often irregularly lobed, scabrous on both surfaces as well as on the margin, palmatinerved and very distinctly veined, slightly convex, thin, yellowish-green above, less shining and lighter below.

The second pair, or the third alternate leaf, or the first one above the lower pair of the usual palmatilobed form, have a tendril in the axil of the petiole.

Trichosanthes cucumerina, *L.* (fig. 381).

Primary root long, tapering, much branched especially near the base.

Hypocotyl undeveloped, subterranean.

Cotyledons oblong-ovate, obtuse, plano-convex, fleshy, narrowed at the base to very short petioles, bursting the testa during germination, and partly or not at all expanded, strictly subterranean, conforming in outline to the shape of the seed.

Stem terete, hairy, climbing by means of tendrils: 1st internode elongated.

Leaves simple, palmately five-lobed, and three- to five-nerved, hairy or downy on both surfaces, alternate, exstipulate.

No. 1. Ovate, three- or incipiently five-lobed, five-nerved with the middle pair of nerves arising at some distance above the base.

Nos. 2–5, inclusive. Palmately five-lobed, trinerved with the nerves of the lower lobes arising as branches from above the base of the middle pair.

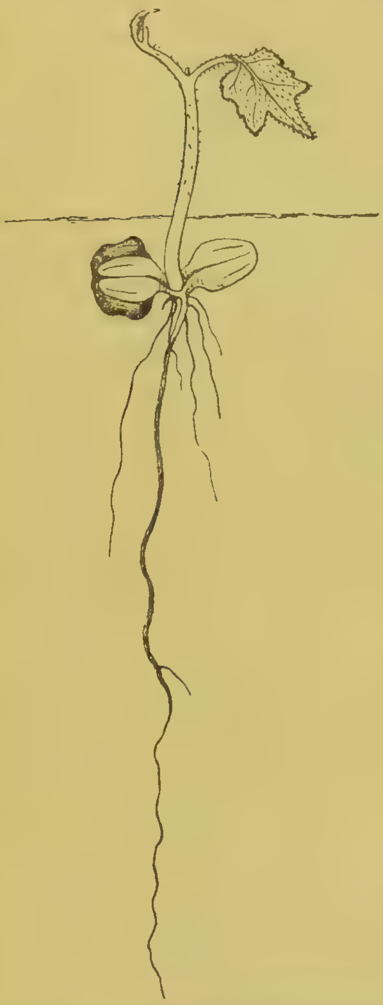

Fig. 381.—*Trichosanthes cucumerina.* Nat. size.

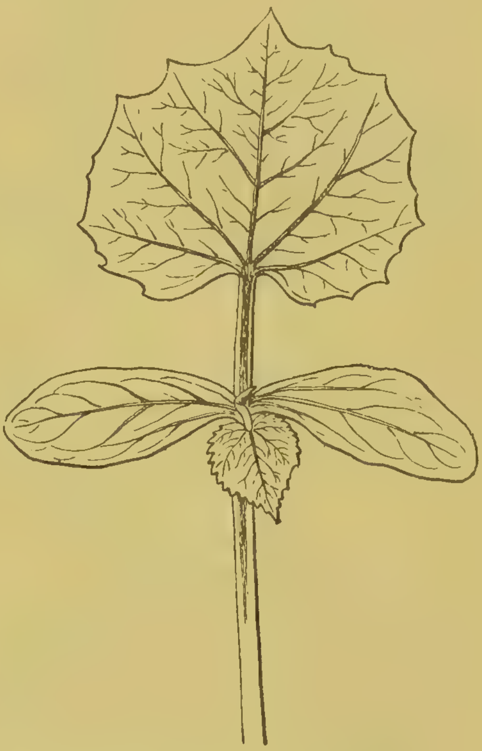

Fig. 382.—*Trichosanthes palmata.* Nat. size.

Trichosanthes palmata, *Roxb.* (fig. 382).

Hypocotyl succulent, 3–4 cm. long, 2–3 mm. thick, channelled above, round near the base, glabrous, whitish-green.

Cotyledons sessile or subsessile with connate, decurrent petioles, 2·5–3 cm. long, 1–1·25 cm. wide, elliptic, obtuse, scabrous, margin recurved, yellowish-green above, whitish below, rather persistent; nerves distinct and pinnate.

Stem suberect at first, ultimately climbing, quadrangular or ridged with dark green, edges hairy; the first few internodes very short, nearly as thick as the hypocotyl, the subsequent ones several centimetres long.

Leaves simple, cauline, alternate, petiolate, palmatinerved and reticulate, toothed, ultimately palmately three- to five-lobed, scabrous, deep green above, paler beneath; petiole semiterete, channelled above, tapering slightly upwards from a stout base.

No. 1. 4–6 cm. long and 3·5–5 cm. wide, with a stout, channelled petiole nearly half as long as the blade, broadly cordate, sinuate-dentate, often irregularly palmatilobed, each tooth and the acuminate apex ending in a mucro, palmatinerved and obscurely, although closely reticulated, scabrous, rather thick.

No. 2. Similar.

No. 3. With a tendril from the axil and more palmatilobed, also with a deeper notch at the base, and sunk nerves and veins.

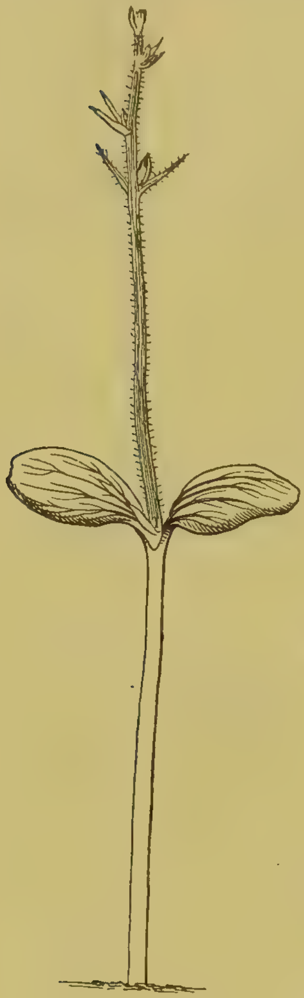

Fig. 383.
Acanthosicyos horrida.
Half nat. size.

Acanthosicyos horrida, *Welw.* (fig. 383).

Hypocotyl very variable in length, erect, succulent, pale green with two short lines of glandular hairs running down from the base of the cotyledons, otherwise glabrous.

Cotyledons ovate or obovate, obtuse, subemarginate, three- to five-nerved, convex above and covered with a short, dense, white, scabrous pubescence, pale, or subglaucous-green, paler beneath, glabrous, shining, five-nerved and subreticulate, 3·15 cm. long, 2·2 cm. wide.

Stem erect when young, succulent, terete, ridged and furrowed, thinly hairy with jointed hairs; ridges pale and furrows deep green; 1st internode undeveloped; 2nd 5·1 cm. long.

Leaves simple, cauline, alternate.

No. 1. Oblong, linear, acute, concave, carinate, entire, 8·25 mm. long.

Nos. 2 and 3. Similar but smaller with a spine on each side at the very base in the position of stipules; spines ridged, furrowed and hairy like the stem.

Nos. 4 and 5. Similar, but more reduced in size.

Momordica muricata, *Willd.* (fig. 384).

Hypocotyl suberect, herbaceous, 5–8 cm. long, 2–3 mm. thick, slightly twisted, glabrous, colourless.

Cotyledons sessile, about 1·5 cm. long, 6–8 mm. wide, oblong, obtuse and recurved at the apex, entire, very obscurely nerved, generally concave, thick, fleshy, glabrous, dark green above, somewhat paler below, rather persistent.

Stem somewhat twisted, slightly pubescent; 1st internode 3·4 cm. long, 2 mm. thick; 2nd and 3rd shorter and thinner.

Leaves.—First pair opposite, 6–9 cm. long, including the petiole, 4–5 cm. wide, long-petioled, rectangular, cordate at the base, the apex and the two adjacent lobes acuminate, sinuate-dentate, palmately seven- to nine-nerved, and richly veined, nearly flat, not very scabrous, bright green above, slightly paler beneath, not very persistent.

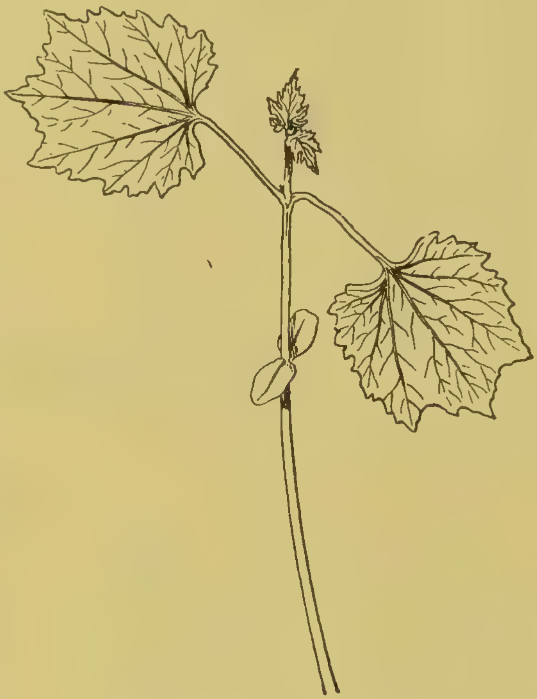

Fig. 384.—*Momordica muricata.* Half nat. size.

Second pair palmately five-lobed and -nerved.

No. 3. and all the rest alternate, and assuming the ultimate shape of the leaf.

Momordica involucrata, *E. Meyer.*

Hypocotyl succulent, 3 cm. long, 2 mm. thick, terete, glabrous, pale green.

Cotyledons sessile, about 1·2 cm. long, 5 mm. wide, 1 mm thick, spathulate, subconnate at base, rotund at apex, entire, obscurely nerved, glabrous, pale green on both sides.

Stem suberect at first, succulent, terete but compressed near the base, quadrangular just under the first two leaves, with a few scattered hairs, light green; 1st internode 3–4 cm. long, 1·5 mm. thick.

Leaves simple, cauline, alternate (first pair opposite), exstipulate, petiolate, palmati-nerved and -lobed, reticulate, pubescent, rather membranous, deep green above, paler beneath; petioles semiterete, tapering slightly upwards, channelled above.

First pair opposite with channelled, slightly pubescent petioles, 2 cm. long and 1·25 mm. thick; lamina 4–5 cm. long, 3–4 cm. wide, broadly cordate with truncate apex, irregularly repand-dentate, palmatinerved and reticulate with sunk nerves, pubescent and dark green above, slightly paler and pubescent on nerves only beneath, not very thick.

Nos. 3–5. Alternate, palmati-nerved and -lobed, cordate at base.

Thladiantha dubia, *Bunge* (fig. 385).

Hypocotyl erect, square, stout, minutely hairy, 1–2 cm. long, light green.

Cotyledons subrotund or orbicular, emarginate (entire at first), petiolate, covered with stiffish hairs on the upper side, glabrous beneath, green, incurvinerved; petioles broad, deeply channelled on the upper side.

Stem erect, terete, hairy, herbaceous; 1st internode 3–4 mm. long.

First leaves simple, cauline, alternate, petiolate, extipulate, subrotund, obtusely crenate or bluntly serrate, cordate at the base, hairy, green, pinnatinerved.

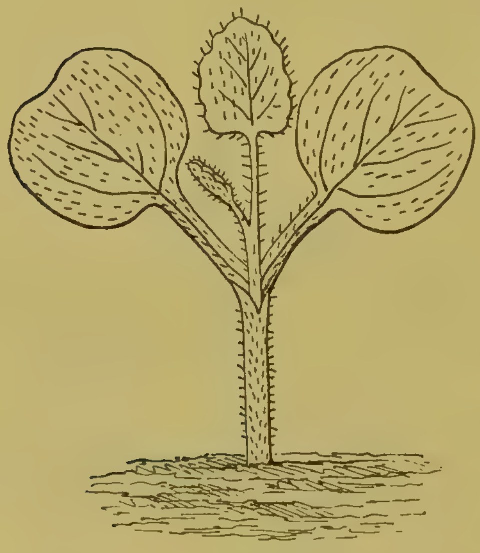

Fig. 385.—*Thladiantha dubia*, × 2.

Cucumis sativus, *L.* (fig. 386).

Hypocotyl quadrangular with obtuse angles and a median furrow along each face, succulent, pale green, pubescent or scabrous on the angles, erect, 5 cm. long, lengthening as it develops to 9 cm., 4 mm. thick.

Cotyledons oblong, obtuse, narrowed at the base into short, broad, deeply-channelled petioles, with ascending nerves, pale green above and scabrous, paler beneath, shining and glabrous, 3 cm. long, lengthening to 6·5 cm., 1 cm. wide, widening to 2 cm.

Stem erect, deeply angled and furrowed, pale green, succulent, coarsely pubescent and scabrous, ultimately flexuose, or zigzag at the nodes, climbing; hairs usually deflexed; 1st internode undeveloped; 2nd 4·5 cm. long; 3rd 1·8 cm.

Leaves simple, cauline, alternate, cirrhose or not, petiolate, coarsely pubescent or hairy on both sides and scabrous; petioles subterete and channelled above, frequently ridged and furrowed especially at the sides. A tendril occurs in the axil of the second or third and succeeding leaves.

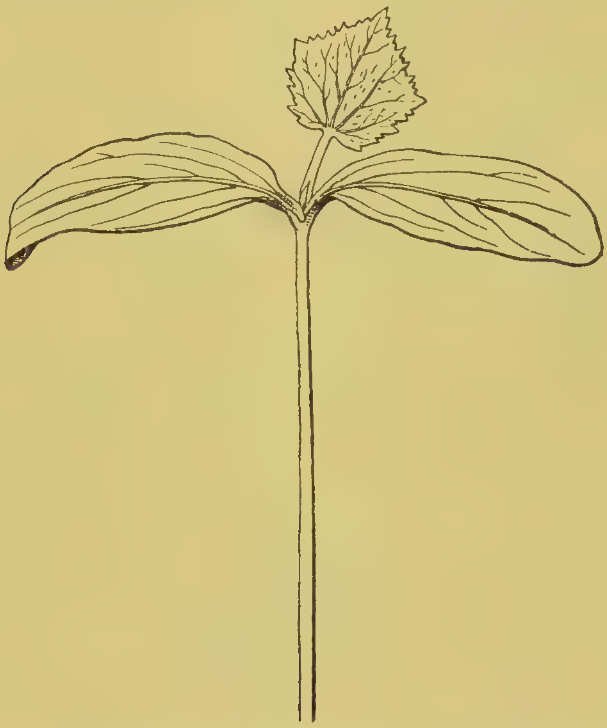

FIG. 386.—*Cucumis sativus.* Nat. size (very young).

No. 1. Lamina broadly cordate, acute, palmately five-nerved, angled or shallowly lobed about the middle at the termination of the nerves, irregularly repand-dentate between the angles or lobes, entire towards the base on each side of the sinus, pale green above with sunk nerves, paler green beneath with prominent nerves and reticulations.

No. 2. More decidedly five-lobed, and toothed almost to the base.

No. 3. Similar.

No. 4. Seven-nerved and -lobed; lobes more decidedly acuminate.

Citrullus Colocynthis, *Schrad.* (fig. 387).

Hypocotyl herbaceous, erect, terete, glabrous, pale green, 1·7 cm. long.

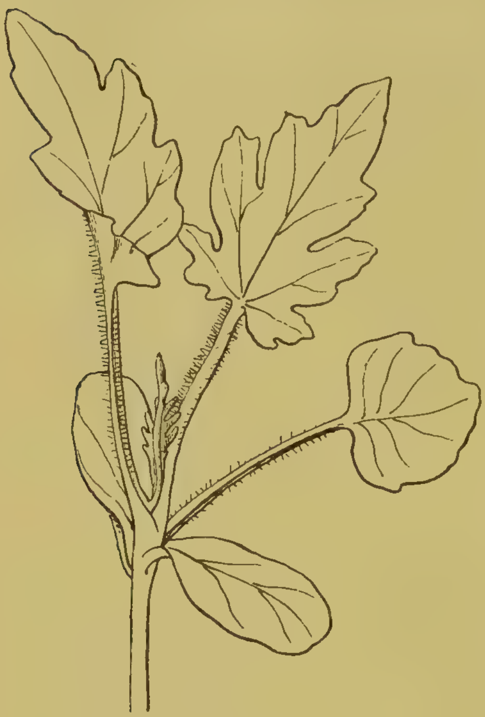

FIG. 387.—*Citrullus Colocynthis.* Nat size.

Cotyledons oblong, obtuse, subglandular on both surfaces, convex above, more or less concave beneath, tapering to a broad, short petiole, 2·1 cm. long, 1 cm. wide.

Leaves cauline, simple, alternate, petiolate.

No. 1. Rotund, obtuse, truncate at the base, obsoletely crenate with many strong nerves, pubescent and scabrous on both surfaces, but chiefly at the margin and on the under side; petiole subterete, channelled above, scabrid with coarse short hairs.

No. 2. Oblong-ovate, subpalmately five-nerved and -lobed; lobes and serratures obtuse, mucronate, otherwise like No. 1.

No. 3. Palmately oblong, five-nerved and -lobed; lobes distinct with obsolete and mucronate serratures; middle lobe largest, ovate.

Cephalandra palmata, *Schrad.* (fig. 388).

Hypocotyl succulent, about 2 cm. long, 1·5–2 mm. thick, obtusely quadrangular, slightly pubescent, light green.

Cotyledons shortly stalked, about 2·5 cm. long and nearly 1·5 cm. wide, oblong-obovate, cuneate at the base, emarginate or bluntly mucronate at the apex, entire, with sunk midrib and two pairs of sunk nerves, rather thick, glabrous, light green above, pale beneath.

Stem with very short internodes (1·5 mm. long), succulent, angular, pubescent, light green, about 1 mm. thick.

Leaves simple, cauline, alternate, exstipulate, petiolate, palmately nerved and lobed, scabrous, pubescent beneath, light green above, paler beneath; petioles tapering slightly upwards, semiterete, channelled on the upper side.

No. 1. With a channelled pubescent petiole 2–2·5 cm. long by 1·5 mm. wide, and a cordate, acuminate, irregularly serrate-dentate lamina, scabrous above, pubescent beneath, light green, thin, palmatinerved and reticulately veined, 3–4 cm. long and about 3 cm. wide.

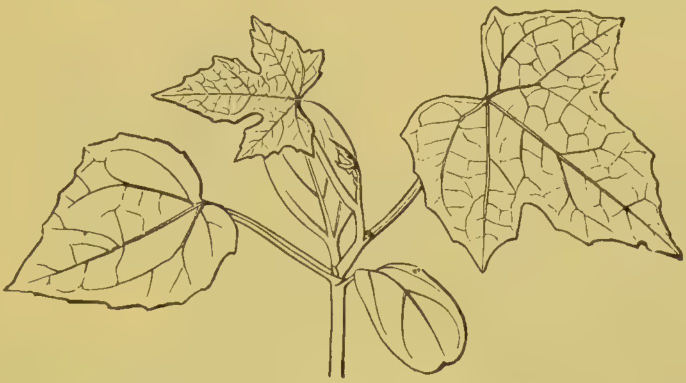

FIG. 388.—*Cephalandra palmata.* Three-quarters nat. size.

No. 2. Distinctly palmately trilobed.

Nos. 3 and 4. Palmately five-lobed like those of the Vine.

Bryonia laciniosa, *L.* (fig. 389).

Fruit baccate, globose, indehiscent.

Seed obovoid, entirely surrounded at the edges with a shallow ridge, compressed at the sides where they are protected by a large semi-obovoid mass of corky-brown matter; micropyle and hilum basal; raphe and chalaza inconspicuous.

Endosperm absent.

Embryo straight, large, occupying the whole interior of the cavity to which it conforms; cotyledons oblong-oval, obtuse, entire, thick or subfleshy, plano-convex, and closely occupying the cavity of the seed, pale yellow; radicle short, turbinate, obtuse, close to the hilum.

Seedling (fig. 390).

Hypocotyl erect, obtusely quadrangular, glabrous, shining, pale green mottled with darker green, and with green lines on the angles and sometimes between, 5·6 cm. above the soil.

Cotyledons foliaceous, obovate-oblong, obtuse, emarginate, trinerved in the basal half, and alternately penninerved in the upper, glabrous on both surfaces, green above, pale beneath, with short petioles; lamina 3·5 cm. long, 2·1 cm. wide; petiole grooved above, 2 mm. long.

Stem erect at first, herbaceous and zigzag, ultimately climbing, five-angled and furrowed, glabrous or slightly bristly, pale green with dark markings; 1st internode undeveloped; 2nd and 3rd each 9·5 mm. long.

Leaves simple, palmate, cauline, alternate, exstipulate, petiolate,

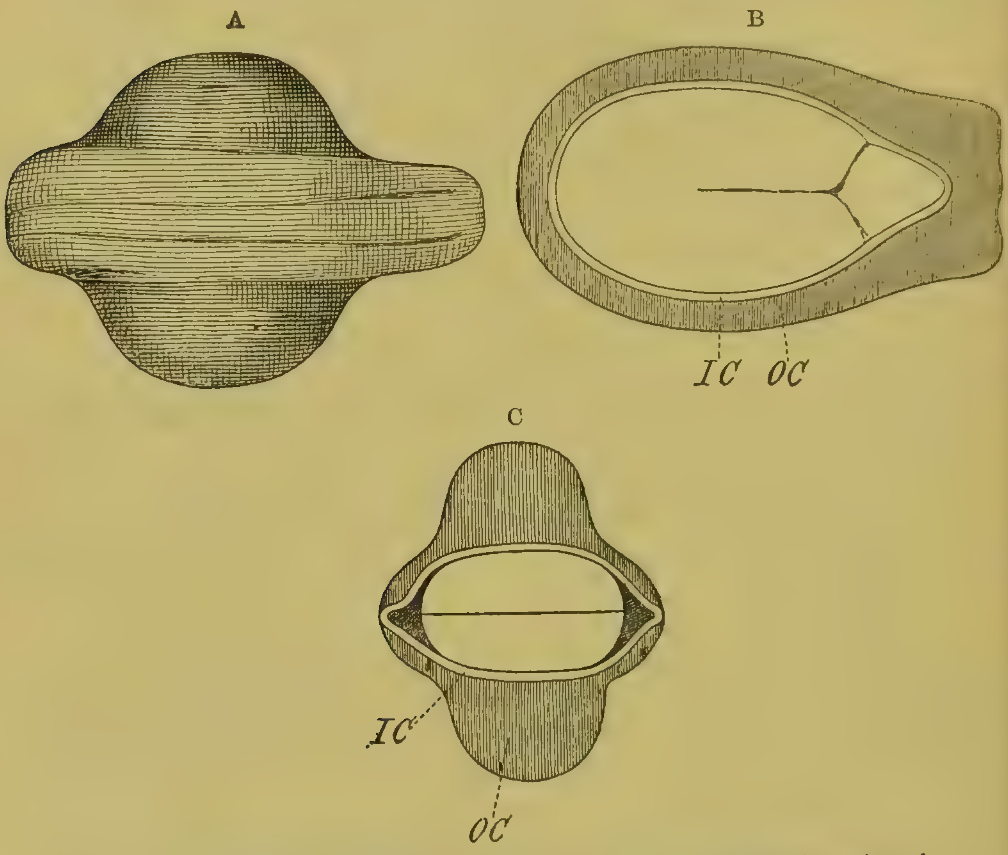

Fig. 389.—*Bryonia laciniosa.* A, seed, × 10. B, longitudinal section of seed: *OC*, testa: *IC*, tegmen, × 10. C, transverse section of seed, × 10.

thinly hairy and scabrous above and deep green, paler beneath, scabrous on the principal nerves, otherwise glabrous; petiole subterete, slightly bristly, channelled above, pale green with darker nerves, shining.

No. 1. Five-nerved, tripartite; middle segment lanceolate-elliptic, acute, distantly dentate; lateral segments obliquely oblong or lanceolate, acute, slightly dentate especially on the oblique side, where a large tooth indicates further division.

No. 2. Similar, but more decidedly dentate.

Nos. 3 and 4. Palmately five-nerved, five-lobed; middle lobe lanceolate-elliptic, acuminate, acute, serrate-dentate, revolute at the margin; lateral lobes lanceolate, serrate-dentate especially on the posterior side; basal lobes small, developed by fission from the lateral or those lobes immediately above them, ovate, acute, dentate mostly on the posterior side, which is somewhat oblique.

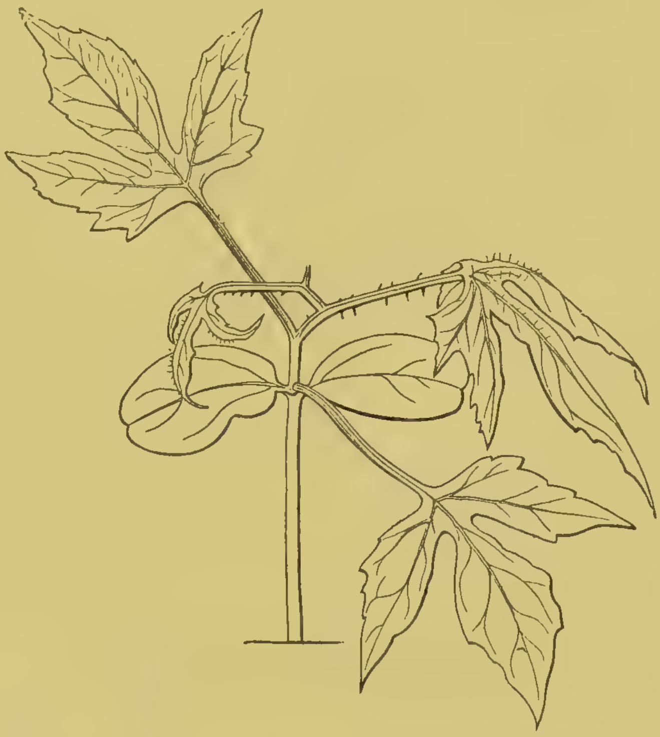

FIG. 390.—*Bryonia laciniosa.* Half nat. size.

Bryonia dioica, *Jacq.* (fig. 391).

Primary root succulent, oblique, colourless, with a few fibres.

Hypocotyl very short, succulent, ridged, about ·5 cm. long, 1·5 mm. thick.

Cotyledons unequal, 1·5–2 cm. long, ·75–1 cm. wide, with pubescent petiole as long as blade, 1–1·5 mm. wide, orbicular or nearly so, suddenly cuneate at the base, rounded at the apex, entire, palmatinerved and coarsely reticulate, pubescent, thin, light green, not very persistent.

Stem suberect at first, ultimately climbing by means of tendrils, not quite 1 mm. thick, angular, pubescent, pale green; 1st internode about 1 cm long; the others 1·5–2 cm.

Leaves simple, cauline, alternate, exstipulate, petiolate, ultimately palmately nerved and lobed, reticulate, pubescent, scabrous, deep green above, paler beneath; petiole rather slender, semiterete, channelled above, hairy.

No. 1. Long petioled, 2–3 cm. long, 1–1·5 cm. wide, cordate or subcordate, sinuate-dentate or lobed, with part of the blade often aborted, acuminate, palmatinerved, pubescent approaching to scabrous, dark green above, very slightly paler below.

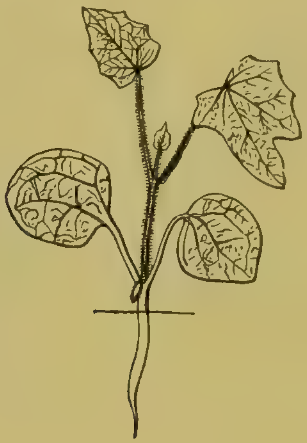

FIG. 391.—*Bryonia dioica.* Nat. size.

No. 2. Similar, but more ovate and uniformly sinuate-dentate and lobed.

No. 3 or 4. As in the preceding species.

Tendrils do not appear as a rule before the sixth or seventh node.

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A CONTRIBUTION

TO OUR

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BEGONIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 841.

Fruit and Seed.—The ovary of the Begoniaceæ is as a rule wholly inferior. That of Hillebrandia forms an exception, being free for a short distance at the apex. Most frequently it is three-celled with three wings or angles, rarely one-, two-, four-, or many-celled. The placentas are axile and simple, or consist of two plates, or are branched and project into the cavity of the ovary; in the case of one-celled ovaries they are thick and spongy. The ovules are very numerous, most often covering the whole surface of the placentas and anatropous. The fruit is capsular, dehiscing loculicidally or rarely septicidally; but a few species of Begonia have baccate fruits bursting irregularly. Those of Hillebrandia dehisce by a large opening between the styles and above the calyx-segments. The capsule of this genus also differs from the prevailing type by being hemispherical and wingless. The mature fruit has the same number of cells as the ovary, and contains very numerous minute seeds of an oblong or cylindrical outline, with a membranous reticulate testa. Endosperm is wanting, or is reduced to a thin layer surrounding the embryo. The latter conforms to the outline of the seed, and has very short cotyledons, with an elongated radicle, or both may be comparatively stout and of equal length.

Seedlings.—Where the seed is minute the seedling must also necessarily be small, but the outline of the cotyledons depends greatly upon the presence or absence of endosperm. The latter has also a great influence upon the size of the seedling both during and after germination. As endosperm is generally absent the seedlings are minute and of slow growth in the early stages. The cotyledons of Begonia villosa (fig. 392) are roundly elliptic, entire, shortly petiolate, and close to the ground owing to the shortness of the hypocotyl. The first leaf is cordate, entire, and the second reniform-orbicular and crenate, followed by others which are gradually larger, broader and more or less oblique, the latter character being very prevalent in the Order. The seedlings of B. parviflora, B. boliviensis, B. Veitchii, B. Pearcei and other tuberous species agree pretty closely in general characters with the above. The cotyledons of B. modesta (fig. 393) are small, oval, shortly petiolate and both directed to one side of the axis. The first leaf is subreniform, entire and oblique, followed by a second that is larger, serrate at the base and very oblique. The third is still more oblique and irregularly dentate. The behaviour of the cotyledons is apparently due to their being connate by their petioles at the base.

Begonia villosa, *Lindl.* (fig. 392).

Primary root slender, with comparatively strong adventitious lateral roots near the upper end at a very early stage.

Hypocotyl very short or undeveloped, or suddenly tapered to a blunt point and giving off adventitious roots.

Cotyledons very small, rotund, obtuse, very shortly petiolate, glabrous, light green, with a slender midrib but no other discernible venation; lamina 1–1·25 mm. in diameter; petiole dilated and slightly connate at the base, about ·5 mm. long above the connate part.

Stem herbaceous, erect, terete, slightly pubescent; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, more or less pilose on both surfaces when young, with jointed hairs, unequal-sided, with alternate, ascending or incurved nerves, all radiating from near the base, also with the midrib and the principal nerves again giving off alternate ascending smaller branches, bronzy green on the upper surface when unfolding, becoming green with a shining metallic lustre, more or less red beneath ; petioles terete, succulent, pale in the young state, becoming reddish, coarsely hairy with jointed hairs ; stipules ovate or deltoid, acute or aristate, entire or more or less dentate.

No. 1. Cordate, obtuse, entire, deeply auricled at the base, more or less oblique or unequal-sided.

No. 2. Rotund-cordate, more or less oblique, deeply auricled at the base, five- to seven-nerved, shallowly crenate.

No. 3. Broadly and obliquely cordate, obtuse, deeply auricled at the base, crenate, about eight-nerved—three on one side of midrib and four on the other.

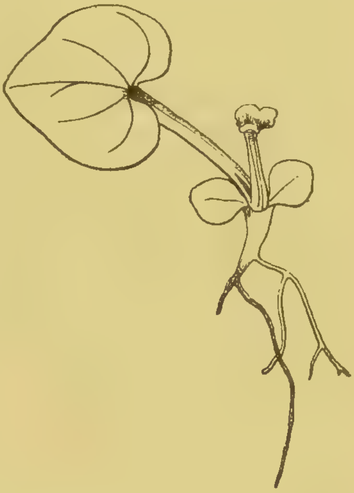

Fig. 392.—*Begonia villosa*, × 4.

No. 4. Similar, but much larger, more elongated with the principal nerves branched, or sometimes having three nerves on one side and five on the other.

No. 5. Similar to the last but more decidedly oblique, and more elongated at the apex where it becomes much narrower.

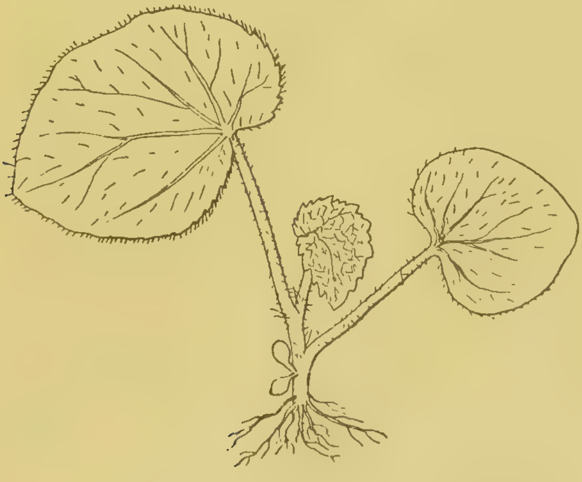

Fig. 393.—*Begonia modesta*. Nat. size.

Begonia modesta, *Liebm.* (fig. 393).

Primary root fibrous, very short.

Hypocotyl 3–4 mm. long, 1·5 mm. thick, succulent, terete, glabrous, brownish.

Cotyledons directed to one side of the axis, shortly stalked, 3-4 mm. long, 2 mm. wide, obtuse lozenge-shaped or oval, rounded at apex, oblique, entire, with obscure midrib, glabrous, pale green.

Stem succulent, terete, pubescent; 1st internode 1–2 mm. long, 1·5 mm. thick; 2nd 3–4 mm. long, 1·5 mm. thick.

Leaves.—No. 1. Lamina 1·5 cm. long, 1·75 cm. wide, broadly cordate, obtuse at apex, entire, palmatinerved, membranous, pubescent, bright green above, paler and glabrous below; petiole 1·5–2 cm. long, pubescent.

No. 2. Obliquely cordate, obtuse, obscurely serrate, ciliate and pubescent on both surfaces as well as the petioles.

No. 3. Serrate, and more oblique.

CACTEÆ.

Benth. et Hook. *Gen. Pl.* i. 845.

Fruit and Seed.—The one-celled ovary is quite inferior. The exterior is smooth or more often covered with scaly bracts or little tufts of bristly hairs or prickles. The placentas are variable in number, but are usually numerous, and parietal, bearing numerous horizontal and anatropous ovules. The fruit is smooth or variously covered with the aborted remains of adnate sepals, and baccate or pulpy when mature. The placentas also form a pulpy mass in which the seeds lie embedded. The latter are oblong or reniform and laterally compressed, or thick and rounded. The testa is crustaceous or bony, of great thickness and dark brown or black, smooth, granulate or covered with small depressions as in some of the Passifloreæ. Endosperm is scanty, copious, or almost wanting, and is generally unequally distributed especially in reniform or curved seeds. The embryo varies greatly in different species, being curved, hooked or straight, club-shaped or cylindrical. The cotyledons are of some length, or short, or the embryo may be merely emarginate, making them appear as if they were connate. In other cases they are fleshy, plano-convex or foliaceous. The stout radicle is conical and short, or cylindrical and elongated. The simplest type of embryo observed is that of Mamillaria longimamma. The seed is obovoid, often more or less compressed laterally, and its interior is entirely occupied by the embryo which conforms to it. There is no separation into radicle and cotyledons, but the whole forms an obovoid mass slightly narrowed at the end next the hilum, which may be considered as representing the radicle. The presence of cotyledons is merely indicated by a shallow triangular notch at the apex. From these circumstances and from the behaviour of the seedlings after germination, the greater part of this thick, short and fleshy embryo must be considered as the hypocotyl which has assumed a succulent state, and acts as a storehouse of reserve-material for the use of the young plant. More differentiation is shown by Echinocactus Wislizeni. The obliquely oblong or subreniform seed contains a small quantity of subfarinaceous endosperm round one end of which the cotyledons are curved or bent so that the embryo presents an oblong, stout, fleshy body hooked at one end. The embryo of Cereus Napoleonis (fig. 395) is very similar to that of Echinocactus Wislizeni, but the cotyledons are more bent, and the seed is suborbicular and much compressed with a deep indentation at the hilum. The walls of the testa are very unequally thickened, the greatest thickening taking place round the end of the seed distant from the hilum. Endosperm is wanting, and the curvature of the embryo is brought about by a thickening of the testa and the indentation at the hilum. In Opuntia Rafinesquii the seed is reniform or suborbicular, subcompressed, and the embryo is curved round the greater part of the periphery of the seed, enclosing in the curve a quantity of farinaceous endosperm, and greatly resembling what occurs in most of the Caryophylleæ, Phytolaccaceæ, Chenopodiaceæ, and other allied Orders. The cotyledons are plano-convex and linear. There is more complication in Opuntia Dillenii (fig. 399), where the embryo is on the whole curved, but bent or angled three times transversely, enclosing a small quantity of endosperm. The cotyledons are plano-convex and subulate-linear. The large orbicular and compressed seed is very much thickened round the periphery.

Seedlings.—The form of the embryo and its parts in the seed have a direct bearing upon the form of the seedling with its cotyledons. We meet with cotyledons of various lengths and shapes, and in some cases they may be considered as absent, or at all events functionless, although morphologically represented. In the seeds of Mamillaria longimamma they appear as the edges of a three-cornered cleft, and in the seedling of M. Goodrichii they are not more conspicuous and soon become indiscernible. Similar instances are furnished by Echinocactus viridescens (fig. 394) and E. Orcuttii. The seedling of the first named, eleven months after sowing of the seed, appears as a small obovoid body representing a short fleshy turbinate hypocotyl bearing minute tooth-like cotyledons, above which the short stem is even stouter, leafless, and covered with small spines in tufts arranged in five or six longitudinal rows. Seven months after the sowing of the seeds, E. Orcuttii is similar to E. viridescens, but smaller.

The cotyledons of Echinocactus Wislizeni attain some size in the seed, but after germination they become merged in the succulent stem by the swelling of the latter, so that seven months after sowing they appear as small triangular teeth about 1 mm. long, and of the same breadth, projecting from the sides of the seedling. About four months after sowing, the cotyledons of Cereus tilophorus borne by the clavate succulent hypocotyl were 1·25 mm. long, and 2 mm. wide. Those of Cereus Napoleonis after three months were 1·5 mm. long, 2·5 mm. wide, triangular and succulent. The hypocotyl in this case is turbinate and very short. The seeds of this species are comparatively small, and so is the seedling during and after germination. Seven months after sowing it is much larger, with the cotyledons about 3 mm. long, and as wide. Strikingly different from all of the above are the seedlings of Opuntia basilaris (fig. 398). The hypocotyl is cylindrical or slightly compressed, but much less succulent than any of the above except that of Cereus tilophorus. The cotyledons are subulate, bluntly pointed, 1·5–3·5 cm. long, and after a time become disarticulated from the axis. They are also of unequal lengths. Abnormal forms occur, having only one cotyledon, while one of them in other cases is bifid. Other species of Opuntia observed not only differ from most members of the Order, but also remarkably from the last species mentioned. The hypocotyl of O. Labouretiana is subterranean, and the cotyledons are ovate, obtuse, fleshy, and very unequal, the larger one being about 2 cm. long, and 1·5 cm. wide, and the shorter one 1·5 cm. long, and 1 cm. wide. They are deep green and persistent. Those of O. occidentalis (fig. 400) are similar, but smaller in every way. In both of these species true leaves occur—a very unusual occurrence in the Order. They are small, subulate, succulent, seated on little elevations of the stem, surrounded by fascicles of spines and arranged in ascending spiral rows; but as they become yellow and fall away early, they are comparatively functionless. Large foliaceous and persistent leaves occur in the species of Pereskia. The cotyledons of Phyllocactus stenopetalus (fig. 397) are similar to those of Opuntia occidentalis and O. Labouretiana; but are very much larger. The hypocotyl is terete and unusually elongated, while the stem is much flattened and leafless, with fascicles of short bristles at the nodes along the edges. The genus Nopalea is closely allied to Opuntia, and N. dejecta resembles Opuntia basilaris in its hypocotyl, which is cylindrical and 1·6 cm. long; but the large ovate fleshy cotyledons, the conical fleshy stem, and the small caducous leaves resemble those of Opuntia Labourtiana.

Mamillaria Goodrichii, *Scheer.*

Primary root small, tapering, with very few lateral rootlets, but numerous root-hairs.

Hypocotyl succulent, ovoid at first and afterwards globose, glabrous, pale transparent green, suffused with pale purple, 2·5 mm. long, 3·75 mm. broad.

Cotyledons represented by the margins of a cleft at the apex of the hypocotyl, and soon becoming indiscernible.

Stem succulent, developing very slowly and crowned in the seedling stage with tufts of short slender spines; spines pink, ultimately white, pubescent, about equal in size.

Leaves none or represented by the above-mentioned spines or bristles.

Echinocactus viridescens, *Nutt.* (fig. 394).

Primary root short, tapering, with a few fleshy lateral rootlets, and abundance of root-hairs.

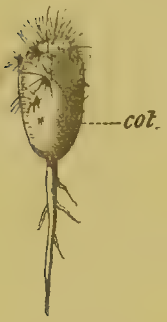

Fig. 394. *Echinocactus viridescens.* Nat. size.

Hypocotyl succulent, short, erect, but distinctly thinner than the stem, pale transparent green, suffused with purple, and mottled with pale markings, 4·5 mm. long, 6 mm. thick.

Cotyledons reduced to minute, scarcely elevated green teeth.

Stem succulent, erect, oblong or globose in the seedling stage, glabrous, shining, coloured like the hypocotyl, slightly five- or six-angled and furnished with tufts of spines in as many rows; spines unequal with usually the central one much longer, red or pink when young, ultimately white, pubescent and seated on the top of little elevations of the stem in a cushion of short cottony or woolly hairs.

Leaves none.

The seedling of **Echinocactus Orcuttii**, *Engelm.*, closely resembles that of the last species.

Cereus Napoleonis, *Hook.* (fig. 395).

Fruit baccate, scaly, one-celled, many-seeded; pericarp pulpy.

Seed irregularly suborbicular, and angled, compressed, glabrous, black, minutely tuberculated all over, but most conspicuously along about half its margin which is bordered with a ring of thickened tissue; testa much thickened, crustaceous or almost bony; tegmen much thinner, membranous, pale-coloured, finely reticulated; hilum very large and conspicuous, forming a deep bordered pit at the base of the seed; micropyle contiguous, inconspicuous, and appearing lateral owing to the size of the hilum.

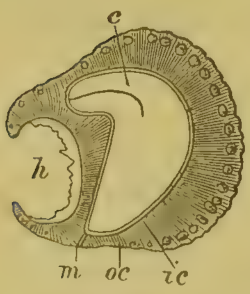

Fig. 395. *Cereus Napoleonis.* Longitudinal section of seed, ×9: *h*, hilum; *m*, micropyle; *oc*, testa; *ic*, tegmen; *c*, cotyledon.

Endosperm wanting.

Embryo bent or hooked, or hammer-like, occupying the whole interior of the seed, fleshy, colourless; cotyledons short, oblong, obtuse, entire, semiterete, fleshy, placed with their edges to the compressed sides of the seeds and consequently in the narrow way of the latter, bent at right angles to the radicle; radicle about as long as the cotyledons, oblong, suddenly tapered to a turbinate obtuse point, fleshy, lying close to the micropyle where the wall of the seed is thinner.

Seedling.

Hypocotyl succulent, turbinate or obconical, glabrous, pale transparent green, suffused with pale purple, and mottled with pale grey markings, 3 mm. above ground, tapering to a long more slender base, altogether 1 cm. long.

Cotyledons triangular, obtuse, succulent, horizontal, tapering into the stem with a convex surface both above and below, coloured like the stem, and projecting about 1·5 mm. from it, 2·5 mm. wide at the base, persistent.

Stem succulent, obtusely five-angled, glabrous, coloured like the hypocotyl, with rows of slender, pink or white, minutely pubescent bristles on the angles.

Leaves none.

Cereus Emoryi, *Engelm.* (fig. 396).

Primary root tapering, stout with lateral rootlets closely clinging to the soil.

Hypocotyl turbinate, very stout and fleshy, glabrous, purple, mottled with white, about 5 mm. long.

Cotyledons short, very fleshy, perfoliate, amalgamated with the hypocotyl and the stem, with spreading or slightly decurved, triangular, acute points, convex on both surfaces and coloured like the hypocotyl; free points about 3 mm. long, and as wide or wider at the base.

Stem fleshy, or succulent, erect in seedling stage, oblong-ovoid, glabrous and glossy, green, slightly suffused with purple, covered with stellate tufts of white, or pale brownish bristles in seven to eight longitudinal rows; about 1·5–2 mm. between each tuft, and 1·5–3 mm. between the rows.

Leaves none.

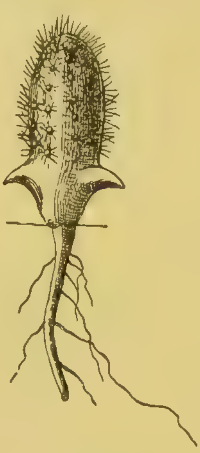

Fig. 396.
Cereus Emoryi.
Nat. size.

Cereus tilophorus, *Pfeiff.*

Hypocotyl succulent, clavate, pale purple mottled with pale grey, glabrous, about 7 mm. above ground.

Cotyledons succulent, triangular, obtuse, horizontal, 1·25 mm. long, 2 mm. wide at the base, coloured like the hypocotyl, persistent.

Stem succulent, erect, glabrous, coloured like the hypocotyl, and furnished with tufts of slender, white, glabrous bristles seated on the top of little woolly-capped elevations, in five or six rows.

Leaves none.

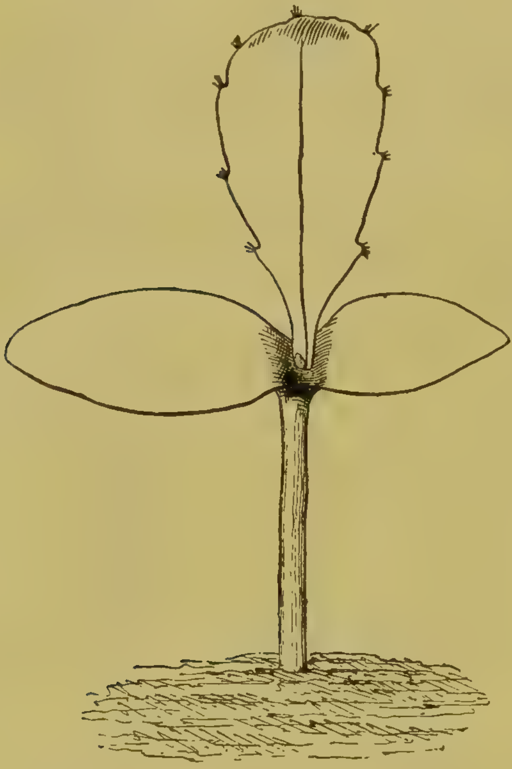

FIG. 397.—*Phyllocactus stenopetalus.* Nat. size.

Phyllocactus stenopetalus, *Salm-Dyck* (fig. 397).

Hypocotyl stout, erect, terete, glabrous, 1·8–2·4 cm. long, green.

Cotyledons ovate or oblong, fleshy, acute, entire, sessile, connate at the base, very unequal, glabrous, green, without any venation.

Stem fleshy or succulent, erect, much flattened, leafless, with small tufts of hairs or bristles at the nodes, otherwise glabrous, crenate or notched along the edges.

Opuntia Rafinesquii, *Engelm.*

Fruit a fleshy pulpy berry, many-seeded.

Seed subrotund or oblate, much flattened laterally; testa hard, bony, rugose; hilum rather conspicuous.

Endosperm scanty, farinaceous, surrounded by the embryo and white.

Embryo curved, lying on the outside of the endosperm; cotyledons linear, curved at the end, obtuse, entire, lying the narrow way of the seed with their faces to the axis; radicle slightly longer than the cotyledons, incumbent, terete, obtuse.

Opuntia basilaris, *Engelm. et Big.* (fig. 398).

Primary root short, succulent, woolly, tapering downwards, with a few short, lateral, fibrous rootlets.

Hypocotyl succulent, 1–2 cm. long, 3–4 mm. thick, slightly compressed, glabrous, of a dull bronze colour, reddish later.

Cotyledons sessile, 1·5–3·5 cm. long, about 4 mm. thick near the base, subulate, similar to the hypocotyl in outer appearance, showing no pulvinus till after the suberect position is changed to a horizontal one, not very persistent.

One of the two cotyledons is sometimes bifid, and occasionally only one is present.

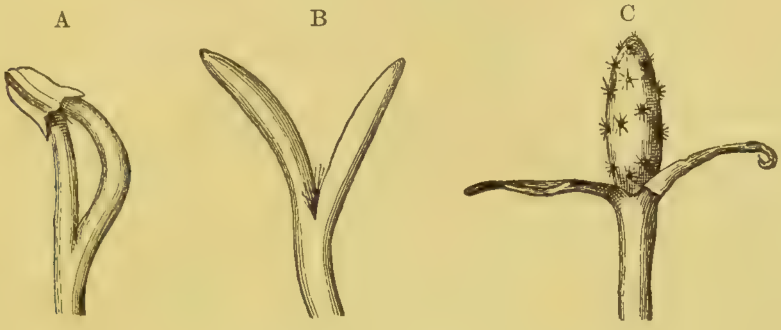

FIG. 398.—*Opuntia basilaris.*
A and B, stages in germination. C, seedling. All nat. size.

Stem conical, succulent, about 5 mm. thick at first, green, with acicular spines projecting in a substellate manner from slightly tomentose protuberances arranged spirally around the young stem.

Opuntia Dillenii, *Haw.* (fig. 399).

Fruit baccate, pyriform, tuberculate, one-celled, many-seeded, with the seeds embedded in pulp.

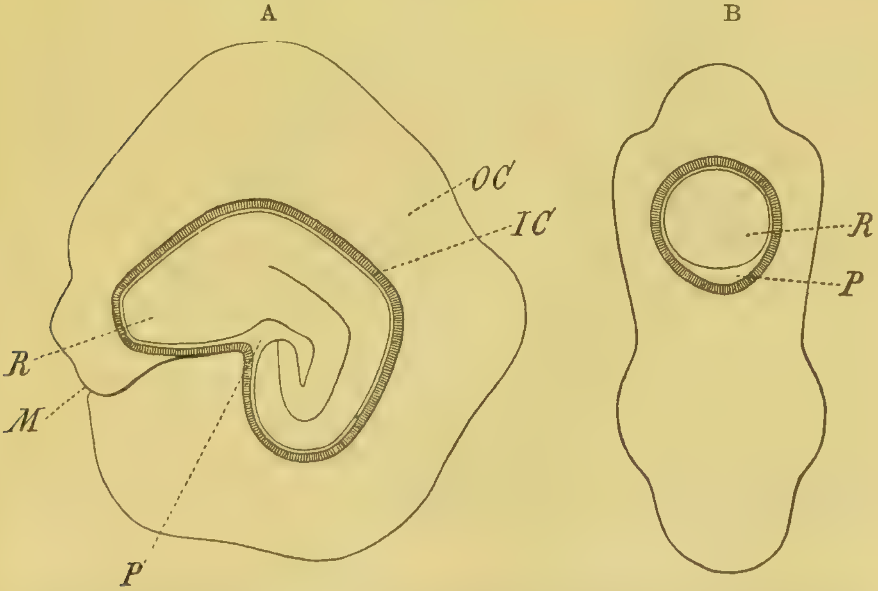

FIG. 399.—*Opuntia Dillenii.* A, longitudinal section of seed, × 9: *R*, radicle; *M*, micropyle; *P*, endosperm; *OC*, testa; *IC*, tegmen. B, transverse section of seed near base, × 9: *R*, radicle; *P*, endosperm.

Seed large, orbicular, laterally compressed, pale brown or whitish; testa thickened, hardened, almost bony, forming a strong marginal ridge all round the seed except at the hilum and micropyle, and also a submarginal ridge on each face; tegmen black, crustaceous, closely adhering to the testa, brownish on its inner face and finely reticulate; micropyle and hilum contiguous, basal.

Endosperm in the mature seed scanty, white, subfarinaceous, generally forming a thin layer surrounding the embryo, but thickest in the angle formed by the curve of the latter and leaving an evident trace there when it has all been absorbed elsewhere.

Embryo curved or hooked, large, assuming this shape from the enormous thickening of the testa, almost colourless when dry, white when moist; cotyledons subulate, linear, obtuse, entire, plano-convex or semiterete, considerably narrowed to the sharply incurved tip, incumbent; radicle short, oblong, obtuse, bent nearly at right angles to the cotyledons, lying close to the micropyle where the testa is thinnest.

Opuntia occidentalis, *Engelm.* (fig. 400).

Hypocotyl subterranean, stout, tapering downwards, pale purple.

Cotyledons succulent, unequal, ovate, obtuse or tipped with a cartilaginous point, nearly flat above, convex on the back; glabrous, shining, deep green, mottled with minute pale grey markings; larger one 1·85 cm. long, 9 mm. wide; shorter one 1·4 cm. long, 7·5 mm. wide, persistent.

Stem succulent, erect, glabrous, deep green, shining, leafy, ultimately naked or without leaves, and furnished with tufts of long, slender, glabrous, bristly, white spines, springing from woolly cushions, in numerous rows; internodes very short, each about 2 mm. long.

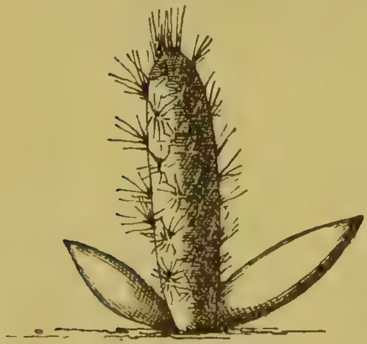

Fig. 400.—*Opuntia occidentalis.* Nat. size.

Leaves small, numerous, succulent, forming longitudinal spiral rows on the stem, subulate, or narrowly conical, acute, glabrous, dull green, seated on little elevations of the stem, 1·5–2·25 mm. long, ·5–·75 mm. wide, deciduous.

The seedling of **Opuntia Labouretiana**, ? *Auct.*, closely resembles the last, but has its unequal cotyledons wider, and the young stem clavate.

FICOIDEÆ.

Benth. et Hook. *Gen. Pl.* i. 851.

Fruit and Seed.—The ovary is inferior in Mesembryanthemum and Tetragonia, but in other genera it is usually surrounded by the persistent calyx. The carpels vary from four to twenty, and unite so as to form an ovary of as many cells. The ovules are solitary and basal, or suspended from the top of the cell, or they are numerous and arranged on placentas attached to the inner angles of the cells, and amphitropous. The fruit is capsular, dehiscing longitudinally, or transversely at the apex. In comparatively few cases it is an achene, or drupe, or consists of several lignified pieces, while in other cases it breaks up into cocci or utriculi. The seeds are solitary or indefinite, reniform, globose, or obovoid, with a membranous or crustaceous testa. Endosperm is present in greater or less quantity and in most cases is of a farinaceous character. The embryo is most often more or less curved or subannular, peripheral, and terete, with linear, plano-convex, incumbent cotyledons and a terete radicle.

There are several exceptional forms in the Order, the most marked of which is Adenogramma, consisting of seven species of South African plants having a one-celled, one-ovuled ovary, and a fleshy endosperm.

The ovary of Gisekia is apocarpous, and consists of five carpels, while in Trianthema and sometimes Galenia there is only one carpel. A type of the Order is represented by Tetragonia expansa (fig. 403), having somewhat flask-shaped seeds suspended one from the apex of each cell by a slender funicle. The embryo is terete, and surrounds nearly the whole of the periphery of the endosperm, with the radicle occupying the neck of the seed. The fruit is many-celled, woody, and indehiscent, with generally a seed in each cell. The mode of germination is shown in fig. 404: the embryo pushes its way through the apex of the fruit, where the walls are very thin in places. In order to make their exit through these narrow openings, it is necessary that the cotyledons should be linear.

Owing to the number of seeds and embryos in each fruit there must be a great competition amongst the seedlings in a state of nature, since there is no means of dissemination, as in fruits which dehisce.

Seedlings.—In general characters there seems to be very little variation amongst the cotyledons of this Order, although they vary slightly in detail. Those of Tetragonia expansa, above-mentioned, are the longest and narrowest. Amongst the species of Mesembryanthemum they are broadly or narrowly oblong, rounded at the apex, sessile and connate, or perfoliate at the base, and so succulent that no venation is discernible, except sometimes a faint indication of a midrib.

Mesembryanthemum tricolorum (fig. 401) presents a short and comparatively broad type. The leaves are linear or semiterete, and succulent with the first pair developed close to the cotyledons, or if the seedlings are crowded at some distance from them. The leaves of M. capitatum are also semiterete. The cotyledons of M. serratum and M. echinatum (fig. 402) closely conform to those of M. tricolorum; and the primary leaves are subulate, semiterete or obtusely trigonous and succulent.

A modification of the above type is exhibited in the cotyledons of M. cordifolium, which are broadly oblong, foliaceous, flat but succulent, minutely wrinkled or areolated, 1·2–1·5 cm. long, and 7–9 mm. wide. It is a significant fact that the leaves are also flat and ovate, or subcordate, from the first pair onwards. The cotyledons are however slightly connate at the base. A type with narrow cotyledons occurs in M. pinnatifidum where they are linear-oblong. The primary leaves are radical, but the stem ultimately becomes elongated and procumbent or trailing, with cauline leaves. The first pair are spathulate and entire, followed by others which are sinuately pinnatifid with rounded alternate segments.

Mesembryanthemum tricolorum, *Haw.* (fig. 401).

Primary root short, tapering, giving off a few lateral fibrils; upper part succulent.

Hypocotyl succulent, stout, tapering from the cotyledons downward, variable in length and subsequently giving off a few short rootlets.

Cotyledons connate at the base or perfoliate, sessile, oblong, obtuse, glabrous, pale green, succulent, 5–8·5 mm. long.

Stem erect, terete, ultimately decumbent, thickened upwards from the pair of leaves below to the pair above, deep red, soft, succulent and watery; 1st internode 8–10 mm. long.

Leaves cauline, opposite, decussate, exstipulate, sessile, connate at the base or perfoliate, linear, obtuse, watery, and succulent, glabrous, covered with longitudinal glandular lines which exude a liquid, at least when young, pale green or suffused with red, and more or less crystalline in appearance.

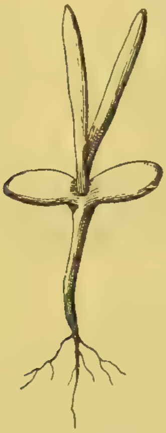

FIG. 401.
Mesembryanthemum tricolorum.
Nat. size.

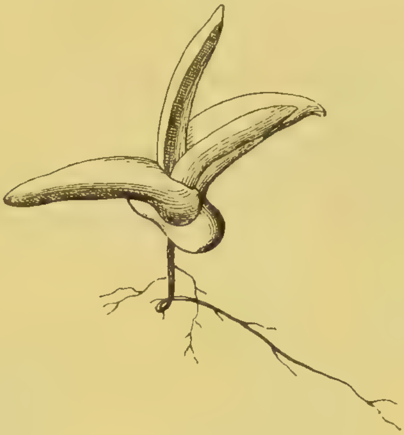

FIG. 402.
Mesembryanthemum echinatum.
Nat. size.

First pair distant from the cotyledons, possibly owing to crowding in the seed-bed.

Second and third pairs crowded when young.

Mesembryanthemum echinatum, *Ait.* (fig. 402).

Primary root slender, tapering, with very slender lateral fibrils.

Hypocotyl subterranean and short, indistinguishably merging into the root.

Cotyledons short, rounded at the end, flattened horizontally, perfoliate, succulent, glabrous.

Leaves simple, entire, radical, opposite, exstipulate, sessile, glabrous, subulate, acute, or subaristate in the young condition, deeply convex on the back and smooth or slightly elevated into rounded and shallow prominences with corresponding depressions between them, flattened on the upper surface and slightly uneven, bright green and shining on both surfaces.

First pair 1·65–2 cm. long.
Second pair 4–6·5 cm. long.
Third pair 4–6 cm. long.

Mesembryanthemum pinnatifidum, *L. fil.*

Primary root fleshy, tapering and giving off lateral rootlets, annual.

Hypocotyl succulent, stout, red, glabrous, about 8 mm. long, 2 mm. thick.

Cotyledons linear-oblong, obtuse, fleshy, flattened above, convex beneath, connate and perfoliate at the base, green often suffused with red, 6 mm. long, 2 mm. wide.

Stem annual, ultimately elongated, procumbent.

Leaves simple, radical and cauline, opposite, exstipulate, petiolate, glabrous, succulent, crowded with glands which cover all parts of the plant, like crystalline papillæ; petioles stout, succulent, channelled above, convex beneath, much dilated at the base and amplexicaul.

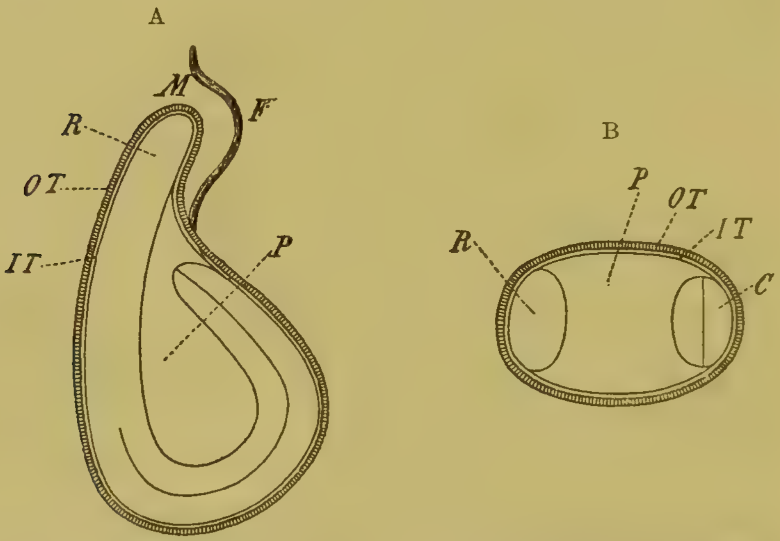

FIG. 403.—*Tetragonia expansa*, × 14. A, longitudinal section of seed: *P*, endosperm; *F*, funicle; *M*, micropyle; *R*, radicle; *OT*, testa; *IT*, tegmen. B, transverse section of seed: *C*, cotyledons.

First pair spathulate, obtuse, entire.

Second pair sometimes similar or somewhat broader, but more frequently oblong, obtuse, shallowly and repandly lobed; lobes rounded, alternate.

Third and fourth pairs oblong, obtuse, pinnatifid; lobes rounded or oblong, entire, alternate, largest at the upper half of the leaf, and smallest towards the base.

Tetragonia expansa, *Ait.* (fig. 403).

Ovary inferior, of many carpels, many-celled, with one pendulous, campylotropous ovule in each cell; micropyle superior.

Fruit a nut, more or less compressed on two sides when dry, variously angled, free at the apex, furnished above the middle with four to five horns, with the three- to five-lobed calyx a little higher up, glabrous or nearly so, but somewhat scabrous, hard and woody when dry, many-celled with one seed in each cell, indehiscent.

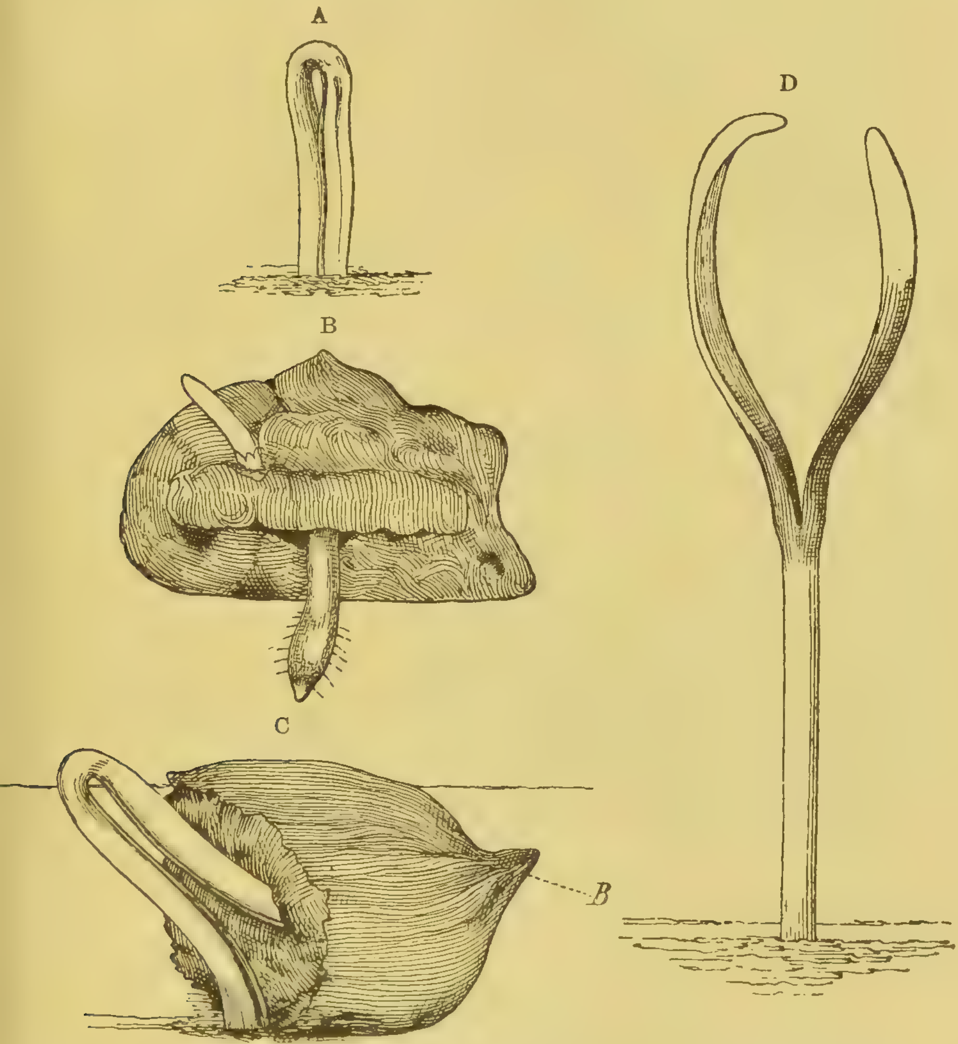

Fig. 404.—*Tetragonia expansa*, × 4 A, seedling from a seed that had been removed from the fruit before sowing. B, fruit soaked in water before sowing. C, another, soaked in water before sowing. D, seedling after it has left the fruit.

Seed suspended from the top of the cell by a long slender funicle, curved and somewhat flask-shaped, owing to the greatly elongated part containing the radicle and micropyle, conforming to the interior of the cell, pale brown, glabrous; testa and tegmen both thin and membranous; hilum at the notch on one side formed by the curvature of the seed; micropyle at a much higher level, being carried up by the elongation of the part containing the radicle.

Endosperm central, of moderate quantity, farinaceous or mealy, pure white.

Embryo large, curved, peripheral, and nearly entirely surrounding the endosperm, almost colourless; cotyledons incumbent, linear, obtuse, entire, plano-convex, lying in the narrow plane of the seed with their backs to the axis of the fruit; radicle terete, obtuse, somewhat longer than the cotyledons, and nearer to the axis of the fruit.

(A) Seedling appearing above ground from a seed taken out of the fruit before sowing.

(B) Fruit that had been soaked in water before sowing. It is many-celled and many-seeded, and the radicles of two germinating embryos are shown. The upper end of the fruit is shown in the sketch.

(C) From another fruit showing upper end, two sides, and the turbinate base, B. The embryo is further advanced in this case. (The fruit had been soaked.)

(D) Whether seed or fruits are sown, the embryo rises clear out of either if properly covered with soil. At this stage (four days after germination) the hypocotyl is glabrous, colourless or reddish at the top, and the cotyledons are linear, obtuse, entire, glabrous and slightly narrowed to the base where they are stained with red.

UMBELLIFERÆ.

Benth. et Hook. *Gen. Pl.* i. 859.

Fruit and Seed.—The ovary is inferior and consists of two carpels united so as to form two cells; it is rarely one-celled by abortion. The ovules are solitary in each cell, suspended from the top, and anatropous. The fruit is a cremocarp, ultimately splitting into equal portions called mericarps, each furnished with five primary ridges and sometimes four secondary ones, with the ridges at the commissure slender or less often developed into wings, sometimes separating from an axial carpophore, and each one-seeded and indehiscent. The walls of the fruit are always dry, and the outer or exocarp is membranous, crustaceous, or thickened and corky. The seed conforms to the cavity of the cell, to the inner wall of which it is adnate, and is flattened, or longitudinally furrowed or concave along the ventral face, or is altogether free. The testa is thinly membranous; and the interior is occupied with a copious cartilaginous endosperm. The embryo is small, close to the hilum, often minute, and ovoid, or larger with ovate or linear cotyledons which may be equal or unequal. The radicle also varies somewhat in length, but is usually short and always superior.

A few exceptional cases occur in the Order, as for instance in Actinotus and Petagnia where the ovary is one-celled, and one-ovuled by abortion, and in Lagoëcia which is monocarpellary. In various species three carpels occasionally appear, while in others, one of the two carpels is imperfect or becomes aborted. The exocarp of Apleura is fleshy, while the endocarp is lignified. The embryo being very small is not of much use in classifying the species of this large Order. The fruits and seeds themselves are however very variable, and although they never attain any great size relatively, their characters are constant, and in systematic classification the form and the flattening, whether dorsal or lateral, the ridges both primary and secondary, and the number of oil cavities or vittæ in the interstices are of the greatest importance for arranging the species into tribes and genera. The tribes again are grouped into three primary series according to the characters of the inflorescence, the ridges and the vittæ.

The fruits appear to fall into five groups according to the form of the mericarps, and the seeds they contain. In all of these groups the cotyledons have their backs to the axis, a few only their edges, but these may be considered as exceptions to the general rule, and will be mentioned by themselves. The groups merely represent types with strongly marked characteristics. The first contains those fruits where the mericarps are more or less distinctly pentagonal. A good type of this kind is furnished by Ptychotis Ajowan (fig. 411). The fruit as a whole is ovate and laterally compressed; and the embryo is shortly linear, and less than half the length of the endosperm. Bupleurum ranunculoides differs chiefly by its oblong fruits and minute obovoid embryo. The primary ridges are acute and much more strongly marked in B. fruticosum than in its congener. The fruit of Fœniculum vulgare has strong blunt ridges and the commissure is by far the broadest face of the mericarp. The embryo is slender and more elongated than in Bupleurum.

The second group is characterised by the triangular outline of the mericarp in transverse section. This is represented by Eryngium giganteum. The fruit as a whole is ovoid, subquadrangular, with four double rows of ascending stiffish scales, and covered with others that are adpressed in the intervening spaces.

The third group is well characterised by fruits much compressed dorsally. The three dorsal ridges of the mericarps are slender; but those at the edges of the commissure are considerably drawn out, yet united with one another so as to form a single wing encompassing the lateral margins of the fruit. They ultimately separate from one another when the mature cremocarp splits into its component halves. The embryo is minute. The mericarps of Peucedanum Schottii are oblong-oval or elliptical and plano-convex, with a narrow wing. Those of Ferula communis are larger and even more decidedly flattened, seeing that they are scarcely convex on the back, and the marginal wing is much broader. Here may be placed Dorema, Lefeburia, Heracleum, Polytænia, Opopanax and others. A slight modification is exhibited by Levisticum, Angelica, Archangelica and others, in which the lateral ridges are not united, but form a double wing encompassing the mericarps. In some genera all the five ridges of each mericarp are drawn out, forming wings as in Pleurospermum and some others. The fruit of Pleurospermum is however more convex or but little compressed dorsally.

In the fourth group the lateral edges of the mericarps are more or less contracted or incurved, making them fluted, or furrowed along the ventral or commissural face. The seeds also conform closely to this peculiar outline, as is best seen in transverse section. This type is well illustrated by Scandix Pecten-Veneris. The fruit is prolonged at the apex into a long, slender, tapering or subtapering beak; the portion containing the seed is linear-oblong. The embryo is slender and rather elongated. Myrrhis odorata differs in having a larger fruit with a shorter beak, the primary ridges prominent and acute; and the embryo seems to be situated near one edge of the seed. The dorsal and lateral ridges of Cuminum Cyminum are the most prominent, while the intermediate ones are small, making the mericarps triangular in transverse outline. The ventral face of mericarp and seed are but slightly grooved; and the embryo is axial. On the other hand, the mericarps of Caucalis nodosa are much infolded at the sides and deeply grooved on the ventral face. The fruits are chiefly remarkable for their dimorphic character. Those on the circumference of the umbel have the outer or most exposed mericarp furnished with a double row of spreading, curved, and hooked bristles on each of the secondary ridges, while the corresponding more protected centripetal carpel as well as all the rest of the fruits are only muricate on the secondary ridges.

The fifth group includes those fruits which are involute not merely at the sides but also at either end, forming a deep cavity on the ventral aspect in each of the two mericarps. This is strongly suggestive of what occurs in Galium amongst the Rubiaceæ. The fruit is didymous, and each mericarp is somewhat globular in Smyrnium perfoliatum. The embryo is axial as usual, but owing to its shortness and to the curvature of the seed it is horizontal with its radicle close to the sublateral micropyle. It is straight or slightly curved and of comparatively large size; and during germination or growth previous to germination it must become considerably curved in order to accommodate itself to the peculiar shape of the seed. A very exceptional case occurs in Trachymene pilosa (fig. 406). The fruit is laterally very much compressed, with the commissure of the mericarps correspondingly narrow. The most striking feature of the seeds, which conform to the shape of the mericarps, is that the embryo has the edges of its cotyledons turned towards the axis, in order to find accommodation during the process of germination in the laterally flattened fruits. The embryo in the transverse section of the mericarp appears to be eccentric, but this phenomenon is due to the mericarp being suddenly narrowed on the dorsal edge near the apex. The fruit of Chærophyllum aureum is narrowly oblong, and dorsally compressed, with the commissural face much the broadest. Contrary to what we should expect, the cotyledons have their edges instead of their backs to the axis, notwithstanding the fact that they lie in the narrowest plane of the seed. Owing to the seed being deeply grooved along the ventral face, the species belongs naturally to the fourth group of which it is an anomalous member. In like manner Carum Carvi (fig. 410) should belong to the first group, seeing that its mericarps are almost regularly pentagonal. The embryo is nearly half the length of the endosperm, but it is very erratic in its behaviour inasmuch as the cotyledons sometimes have their backs to the axis (which is probably the most typical case), sometimes their edges, or again are placed obliquely, that is, diagonally to it. The various inclinations seem to be assumed indifferently, and the embryos even frequently occupy different positions in the two halves or mericarps of each fruit.

Seedlings.—While still in the seed the width of the cotyledons is limited by that of the seed itself.

After germination, however, they may become more or less modified by further growth; but the form they attain in the seed becomes deeply impressed upon them, and the chief alteration is in length, especially in that of the petioles.

Those observed may be arranged in five groups more for convenience' sake than from absolute distinction between the several types, for there is every intermediate gradation. In the first may be classified all those in which the lamina of the cotyledons is short and relatively broad. It varies from ovate, spathulate, and oblong to oval, and is generally if not always distinctly petiolate with the petioles free, or connate at the very base only. The cotyledons of Hydrocotyle vulgaris (fig. 405) are ovate, subsessile, and very small. They exactly correspond with the size and shape of the mericarps. The leaves are peltate, orbicular, and crenate from the first, or, the first one is sometimes reniform and nearly or quite entire. The cotyledons of Trachymene pilosa are oblong-spathulate, trinerved and minutely emarginate. Those of T. pusilla are slightly broader; and both correspond fairly to the shape of the carpels. In their herbage they bear a striking resemblance to the mossy-leaved Saxifrages. The first leaf is trifid, followed by some that are tripartite with cuneate, trifid segments, and ultimately by others that are tripartite with entire segments. The cotyledons of Eryngium paniculatum (fig. 407) are also spathulate, but very small, while the primary leaves vary from suborbicular through spathulate to elliptic with spiny-serrate margins. The first leaves of E. pandanifolium are similar but less prominently spiny-serrate. The first two of Bifora Biebersteinii are broadly triangular and trifid, followed by a pinnatisect leaf, then by another that is two to three times cut in the same way.

The cotyledons are oblong, and trinerved with long petioles; and those of Coriandrum sativum are closely similar. There is also a marked similarity between the primary leaves of both species, as well as the ultimate ones. The cotyledons of Eryngium giganteum are broadly oval and trinerved.

The first two leaves are reniform, followed by others which are cordate in outline, but somewhat variable in detail. The petioles of the cotyledons are elongated and slender. Heracleum Sprengelianum connects this group with the next, for the difference is only one of degree. The elliptic lamina of the cotyledons is three- to five-nerved. The first leaf is cordate, five-nerved, and shallowly five-lobed. The first leaf of Heracleum villosum (fig. 416) is roundly cordate and crenate, while the laminæ of the cotyledons are linear-oblong and sometimes very unequal. Those of Peucedanum sativum (fig. 415) are similar, but occasionally there are three cotyledons, sometimes two and bipartite.

The third group includes a number of species where the lamina of the cotyledons is short, broad and trinerved, but the petioles are elongated and connate into one cylindrical piece, or are much less decidedly connate, sheathing the younger leaves. This peculiar behaviour is due to the hypocotyl being very short or undeveloped and subterranean. The long petioles carry the lamina up to the light, and their union gives strength or rigidity while the material necessary for the production of two strong petioles is economised. This type is well represented by Smyrnium perfoliatum (fig. 408). The combined petioles strongly resemble a slender, terete hypocotyl, and while we are expecting to see the plumule emerge from between the free portions, a leaf makes its appearance from the soil. Examination shows that it proceeds from a cleft at the very base of the united petioles and directly abutting upon the hypocotyl which soon becomes fleshy and tuberous in its nature. The first leaf has a tripartite lamina. During the germination of the embryo the broad cotyledons are able to make their exit from the globular concave seed by the splitting of the crustaceous exocarp. Both this species and S. rotundifolium have emarginate cotyledons, and they, together with S. Olusatrum, closely agree in all main particulars. Ferula fœtida and F. communis may be placed here because their petioles are connate at the base. The petioles with the linear-lanceolate lamina of the former measure about 14 cm. long; but the petioles are connate for a distance of 8–10 mm. only. The first two leaves have a tripartite lamina. The cotyledons of F. communis are very much shorter, trinerved, linear; and the petioles are connate for 7–8·5 mm. at the base. The first leaf is bi- to tri-pinnatisect. The long narrow cotyledons do not correspond with the large oval or elliptic dorsally compressed seeds.

In the fourth group may be included all those species having linear petiolate cotyledons of moderate length, as represented by Bupleurum fruticosum. The first four leaves are obovate, the ultimate ones oblong-obovate. B. longifolium and B. falcatum agree in all respects except in having narrower leaves. The species belonging to this genus are remarkable amongst the Umbelliferæ for their entire leaves. Other species agreeing with the above in respect of the cotyledons are Ammi glaucifolium (fig. 409), Chærophyllum aureum, Carum Carvi, Ptychotis Ajowan, and Daucus Carota. Ammi glaucifolium shows well-marked evolution of the leaves, the first one being suborbicular and dentate; the second and third oblong, subcordate, and finely serrate; while the fourth is tripartite with leaflet-like segments. The first leaf of Carum Carvi is ternately cut nearly to the base; that of Ptychotis Ajowan (fig. 412) is tripartite with cuneate segments; and Daucus Carota is closely similar.

The fifth group includes a number of species with linear or narrowly linear greatly elongated cotyledons. Those of Fœniculum vulgare (fig. 413) are 3–3·5 cm. long. The primary leaves generally show a high state of division. In this case the first is bipinnatisect at the base with linear segments; and the second is three or four times pinnatisect. Cuminum Cyminum, Myrrhis odorata, Scandix Pecten-Veneris and Aciphylla squarrosa (fig. 414) also agree in having narrow cotyledons. Those of Myrrhis odorata vary from 9–11·2 cm. in length, and are distinctly widened above the middle, beneath which they taper into the greatly elongated petiole. The first leaf is bi- to tri-pinnatifid. That of Scandix Pecten-Veneris is tripinnatifid, with short, lanceolate segments; and the second is even more divided. The cotyledons are exceedingly narrow and 6·4–6·8 cm. long. Those of Aciphylla squarrosa are 3·6–4·3 cm. long, narrowly linear, scarcely tapered to the sheathing base, coriaceous and persistent, a very unusual circumstance in the Order. A considerable number of the primary leaves of this remarkable plant resemble the cotyledons, but are several times longer and tipped with a spine. The first three are linear and entire; the fourth with one lateral segment; the fifth with two lateral segments, followed by a number which are again entire. Divided leaves may, however, vary in their sequence in different seedlings. The ultimate leaves are bipinnatisect with linear, entire, spiny-tipped divaricate segments, arranged at least in two different planes.

Hydrocotyle vulgaris, *L.* (fig. 405).

Primary root slender, flexuose, with a few lateral rootlets.

Hypocotyl pale greenish, tapering downwards, about 3 mm. long.

Cotyledons small, subsessile, ovate, obtuse or subacute, glabrous, 2·75 mm. long, 2 mm. wide, petiole about ·5–1 mm. long.

Stem herbaceous, procumbent, creeping and rooting, terete, glabrous, pale green; 1st, 2nd, and 3rd internodes undeveloped; 4th 5·5 mm.; 5th 9·5 mm. long.

Leaves simple, radical, alternate, exstipulate, petiolate, glabrous, peltate, orbicular, crenate.

No. 1. Orbicular, entire, or obscurely crenate, or frequently dentate, sometimes reniform, or if orbicular with a more or less open sinus and not peltate, obscurely five-nerved.

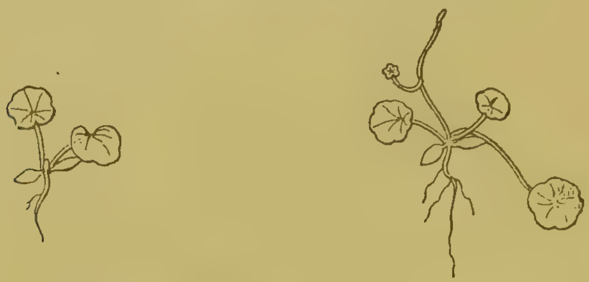
Fig. 405.—*Hydrocotyle vulgaris.* Nat. size.

No. 2. Peltate, seven-nerved and shallowly crenate.

No. 3. Similar but larger.

Ultimate leaves orbicular, peltate, seven- to nine-nerved, and lobulate-crenate or doubly crenate, glabrous and bright shining green above, paler beneath, and very thinly hairy or glabrous; veins slightly branching and reticulate towards the apex; petioles variable in length according to position and moisture, terete, hairy near the top, otherwise glabrous. The plant grows in marshy places.

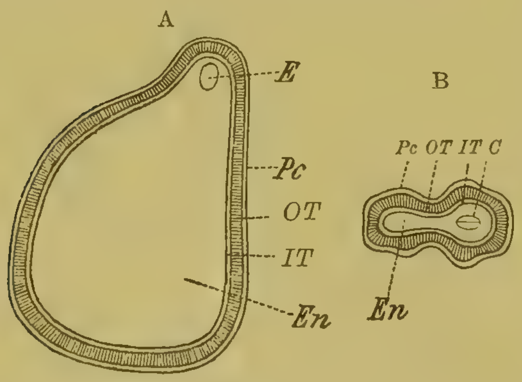

Fig. 406.—*Trachymene pilosa*, × 10. A, longitudinal section of mericarp. B, transverse section: *E*, embryo; *Pc*, pericarp; *OT*, testa; *IT*, tegmen; *En*, endosperm; *C*, cotyledons.

Trachymene pilosa, *Sm.* (fig. 406).

Fruit a cremocarp of two mericarps; commissure very narrow; mericarps laterally compressed.

Seed laterally much compressed, flat, conforming to the fruit.

Embryo minute, straight; cotyledons rounded, short and comparatively broad, lying in the broad plane of the seed with their edges to the placenta, plano-convex; radicle very short, blunt. This position of the embryo is very exceptional in the Order.

Seedling.

Primary root long, tapering downwards, more or less flexuose, with a few lateral rootlets, colourless, annual.

Hypocotyl erect, terete, thinly hairy, and densely covered with small, elevated, gland-like points, deep red, tapering insensibly into the root, 2·4–2·8 cm. long.

Cotyledons oblong-spathulate, petiolate, obtuse, minutely emarginate, with a distinct midrib, alternately trinerved from the middle upwards, but the nerves only visible on the under side, densely pubescent, and more or less glandular on both surfaces, dull green above, paler beneath or stained with red ; lamina 9·5–11 mm. long, 5·5–7 mm. wide, tapered into the petiole ; petiole grooved above, convex on the back, connate at the base, pubescent and more or less glandular, 6·5–7·5 mm. long.

Stem herbaceous, annual, erect, terete, branching and flexuose, or zigzag, densely glandular-hairy ; 1st and 2nd internodes undeveloped ; 3rd ·5 mm. long ; 4th 3–4 mm. ; 5th 1·8–2·2 cm.

Leaves simple, tri-fid, -lobed or -sect, cauline, or the first two radical, alternate, exstipulate, petiolate, palmately trinerved from the base, glandular-hairy on both surfaces, deep green above and shining, much paler beneath ; petiole semiterete, channelled above, glandular-hairy, tapering upwards from a broadish, semi-amplexicaul base.

No. 1. Cuneate, trifid ; segments short, oblong, minutely cuspidate, obtuse.

No. 2. Broadly cuneate, trifid ; middle segment oblong, obtuse minutely cuspidate ; lateral segments oblong, bidentate at the apex ; apices minutely cuspidate.

No. 3. Palmately tripartite ; middle segment spathulate-cuneate, tridentate at apex ; lateral segments obliquely cuneate and unequally trifid.

No. 4. Palmately tripartite ; middle segment spathulate-cuneate, trifid and slightly dentate ; lateral segments cuneate, unequally trifid, and slightly dentate.

Nos. 5 and 6. Deeply tripartite, with narrower segments than the fourth.

The specimens after this were showing flower, while the leaves gradually became reduced, palmately tripartite, with linear, trifid, or tridentate or entire segments.

Like its congener, T. pusilla, it resembles a species of Saxifrage.

Eryngium paniculatum, *Cav.* (fig. 407).

Hypocotyl subterranean.

Cotyledons spathulate, obtuse or emarginate, pale or grass-green 7 mm. long, 3·5 mm. wide, glabrous.

Stem herbaceous and elongated when about to flower.

Leaves simple, radical and cauline, alternate, exstipulate, sessile, dilated and sheathing at the base, glabrous, grass-green and lucid.

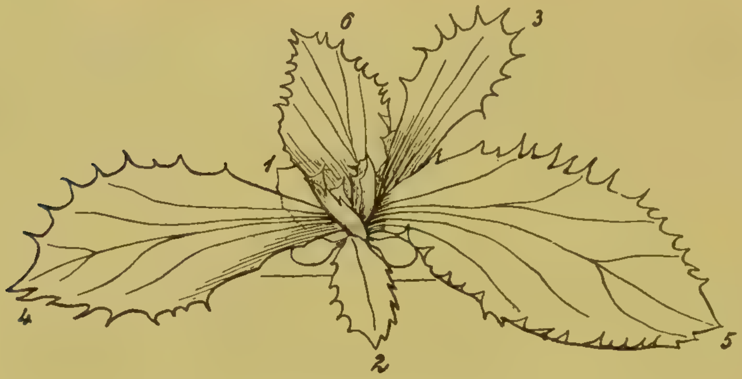

FIG. 407.—*Eryngium paniculatum*, Nat. size.

No. 1. Small, spathulate-rotund, acutely dentate.

No. 2. Small, oblong-elliptic, acutely spiny-serrate.

No. 3. Spathulate, acutely spiny-serrate.

No. 4. Spathulate-obovate, acutely spiny-serrate, and sparsely setose between the serratures.

No. 5. Oblong-elliptical, acute, otherwise like No 4.

Eryngium giganteum, *M. Bieb.*

Hypocotyl very stout, fleshy, colourless, tapering downwards.

Cotyledons foliaceous, petiolate, glabrous ; lamina oval, minutely emarginate, trinerved and reticulate, grass-green, shining, 6 cm. long, 1 cm. wide ; petiole slightly grooved above, 1·6 cm. long.

Stem herbaceous and developed when about to flower.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, bright green, shining, five-nerved and reticulate ; petioles subterete, channelled above, dilated and clasping at the base.

No. 1. Suborbicular, cordate at the base, crenate.

No. 2. Broadly cordate, very obtuse, crenate,

Nos. 3 and 4. Cordate, subelongate, very obtuse, unequally crenate.

Ultimate leaves, both the radical and lower cauline ones, cordate, obtuse or subacute, irregularly crenate-dentate, with long petioles. Middle cauline, cordate-elongate, upper ones cordate, and both sessile, amplexicaul, deeply and acutely spiny-serrate.

Smyrnium perfoliatum *Mill.* (fig. 408).

Primary root very stout, forming a long tapering tap root, biennial.

Hypocotyl undeveloped.

Cotyledons oblong-elliptic, emarginate, obtuse, generally unequal-sided or subfalcate, with long petioles, trinerved from the base and finely reticulate, with the lateral nerves becoming incurved and uniting with the midrib close to the apex, glabrous, light green above, paler beneath, shining on both surfaces; lamina 1·8–2·4 cm. long, 8·5–11 mm. wide; petioles 6–10 cm. long, connate into one terete piece for 5·5–7·5 cm. of their length, split a little way at the base to allow the plumule to emerge, free in the upper part, semiterete and slightly channelled above, glabrous, dull brownish-green.

Stem developed when about to flower; primary internodes undeveloped.

Leaves simple, trisect, ultimately ternately pinnatisect, radical and cauline, alternate, exstipulate, petiolate with the principal nerves opposite or subopposite, the others alternate, all ascending, glabrous, shining on both surfaces, bright green above, paler beneath; petioles semiterete, channelled above, glabrous, shining, dilated and sheathing at the base.

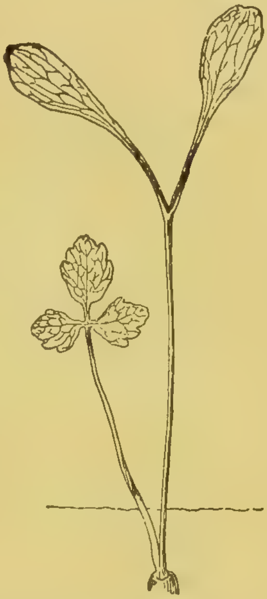
Fig. 408.
Smyrnium perfoliatum.
Half nat. size.

No. 1. Pinnately trisect; lateral segments broadly cuneate, unequal at the base on the posterior side, obtusely dentate-serrate on the upper half; terminal segment equal at the base, otherwise like the lateral ones.

Bupleurum fruticosum, *L.*

Primary root long, tapering, flexuose, colourless, with a few lateral rootlets.

Hypocotyl erect, terete, glabrous, purplish-brown or green 1·2 cm. long.

Cotyledons linear, obtuse or subacute, petiolate, glabrous, deep green with ascending petioles and a spreading or horizontal lamina, 2·4 cm. long including the petiole, 3 mm. wide about the middle of the lamina, slightly tapering to each end.

Stem shrubby, erect, terete, glabrous, green stained with purple where exposed, covered with a glaucous bloom; 1st internode 5 mm. long; 2nd and 3rd each 5·5 mm.

Leaves simple, entire or merely emarginate on the adult plant, cauline, alternate, exstipulate, petiolate, glabrous, finely alternately penninerved, and finely reticulate, deep green above, paler and glaucous beneath, cartilaginous at the margin, apiculate; petioles channelled above, rounded on the back, glabrous, semiamplexicaul, rather long in the seedling, and almost or quite reduced to the sheath in the adult plant.

Nos 1 to 4. Obovate, obtuse, entire, apiculate.

Ultimate leaves oblong-obovate, emarginate, apiculate, with a midrib and two slender submarginal nerves, also two slender nerves at the base on each side of the midrib extending for half to three-quarters of an inch up and uniting each pair into one, which again runs along each side of the midrib till a little above the middle of the leaf, where it unites with the midrib, forming one nerve.

Bupleurum longifolium, *L.*

Primary root and *hypocotyl* as in last species.

Cotyledons linear, subacute, widest about the middle, deep green, glabrous, about 1·3 cm. long including the petiole.

Stem herbaceous, annual, developed when about to flower.

Leaves simple, entire, radical and cauline, alternate, exstipulate, petiolate, glabrous, scabrous on the margin and midrib beneath; petioles dilated and sheathing at the base, ridged and furrowed, channelled above, scabrous on the ridges.

No. 1. Small, obovate-spathulate, apiculate.

Nos. 2. and 3. Obovate, apiculate.

Ammi glaucifolium, *L.* (fig. 409).

Primary root stout, tapering downward, and soon furnished with slender, short lateral rootlets.

Hypocotyl stout, tapering insensibly into the root, glabrous, flesh-coloured.

Cotyledons linear, obtuse, entire, petiolate, glabrous, tapering gradually into the petiole, dilated and connate at the base, forming a cup around the plumule, at length splitting on one side, alternately penninerved, with some of the nerves suddenly curved upwards and running parallel with the margin, while others proceed to the margin almost horizontally, 2·5–2·8 cm. long including the petiole, 2–3 mm. wide about the middle of the lamina which tapers to each end.

Stem herbaceous, erect, terete, glabrous, pale green; 1st internode undeveloped, 2nd 4 mm. long; 3rd 2·5 mm.

Leaves compound, radical and cauline, alternate, exstipulate, petiolate, glabrous, alternately penninerved with flexuose, much branched anastomosing nerves, shining on both surfaces, bright grass-green above, lighter green beneath; petioles semiterete, deeply channelled above, tapering slightly upwards, dilated at the base and forming a long clasping sheath with broad hyaline edges, articulated with the lamina.

No. 1. Rotund, subtrifid and irregularly dentate-serrate, three- or five-nerved towards the base.

No. 2. Oval, obtuse, subcordate at the base, rather finely and acutely serrate.

No. 3. Oblong, subacute or acute, finely and acutely serrate.

No. 4. Similar, or in strong plants pinnately trifoliolate; lateral leaflets lanceolate, acute, sharply serrate, unequal at the base, sessile but articulated with the petiole; terminal one much larger, lanceolate-ovate, acute, finely and acutely serrate.

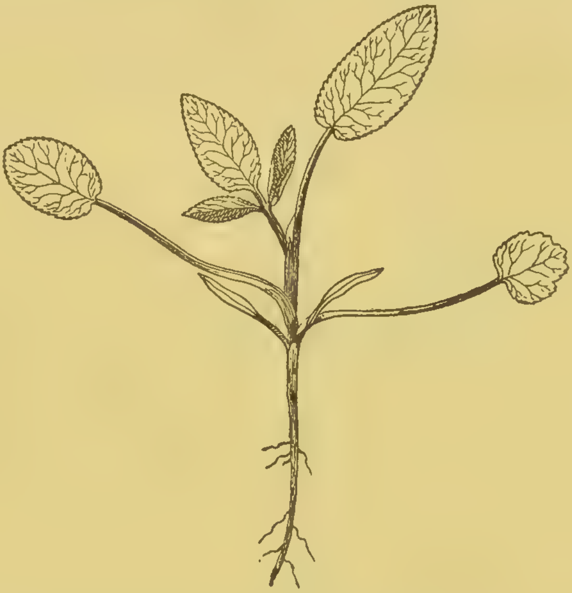

FIG. 409.—*Ammi glaucifolium.* Half nat. size.

Carum Carvi, *L.* (fig. 410).

Cremocarp ovate or oblong, obtuse, tipped by the small persistent calyx-teeth, and the stylopodium, glabrous, laterally compressed, attached to a shortly bifid carpophore and falling away in two pieces (mericarps) when mature; mericarp oblong, slightly curved longitudinally, five-angled and five-sided with the commissural face slightly the broadest, the primary ridges filiform and rather prominent and a comparatively large vitta between each ridge with two on the flattened commissural face, one on each side of a slender median ridge, one-celled, one-seeded, indehiscent.

Seed five-angled, flat on the commissural or ventral face, or showing a scarcely prominent median ridge, shallowly sulcate between the other ridges, filling and closely conforming to the interior of the mericarp; hilum and micropyle contiguous, basal and superior.

Endosperm in the mature seed copious, fleshy, white, or nearly so.

Embryo large for the size of the fruit and the Order, straight, colourless; cotyledons oblong, obtuse, entire, plano-convex, slightly longer than the radicle, lying with their backs or their edges to the axis of the fruit, or diagonally; these positions seem to be taken indifferently, and two of them frequently in the same cremocarp; radicle oblong-terete, suddenly tapering to an obtuse point, close to the micropyle, but with a layer of endosperm surrounding it.

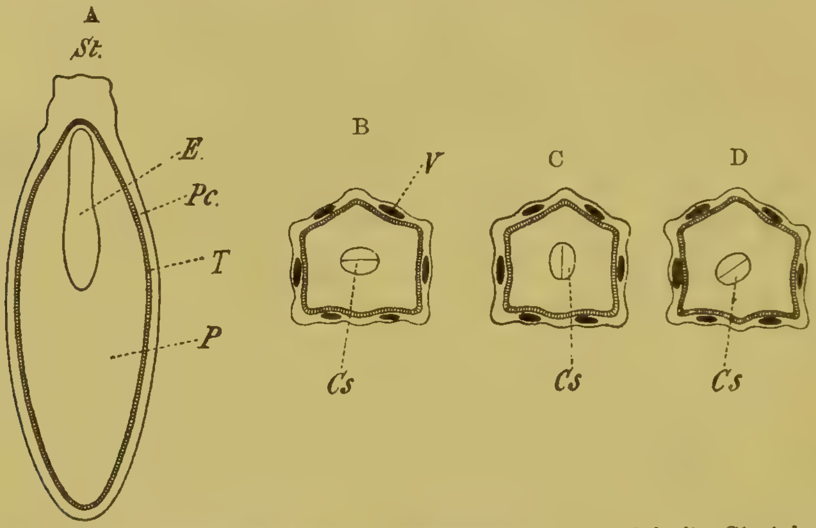

FIG. 410.—*Carum Carvi*, × 10. A, longitudinal section of fruit: *St*, stylopodium; *E*, embryo; *Pc*, pericarp; *T*, testa; *P*, endosperm. B, transverse section of fruit: *V*, vitta or oil canal; *Cs*, cotyledons transversely to the axis of fruit. C, transverse section of fruit: *Cs*, cotyledons at right angles to the axis of fruit. D, transverse section of fruit: *Cs*, cotyledons, obliquely to the axis of fruit.

Ptychotis Ajowan, *DC.* (fig. 411).

Cremocarp ovate, laterally compressed, covered especially on the ridges with hardened protuberances or dried papillæ, tipped by the angled or knotty stylopodium and separating when mature into two mericarps. Carpophore bifid.

Mericarp ovoid with the commissural face the broadest, somewhat curved longitudinally; five-ridged, with the ridges slender, three dorsal and two on the edges of the ventral commissure, with a solitary vitta between each ridge, one-celled, one-seeded, indehiscent.

Seed oblong, subterete, slightly flattened on the ventral aspect, with a shallow, median, longitudinal ridge, closely conforming to the interior of the mericarp, and adhering to it; testa thin, membranous, brown, inseparable from the pericarp; hilum and micropyle contiguous, basal, at the upper end of the seed.

Endosperm in the mature seed copious, fleshy, firm, white.

Embryo minute, straight, colourless, embedded in the endosperm close to the basal end of the seed; cotyledons oblong, obtuse, entire, plano-convex, lying in the centre of the endosperm, with their backs to the central axis of the fruit, and their edges to its compressed sides; radicle oblong-terete, obtuse, about as thick and as long as the cotyledons.

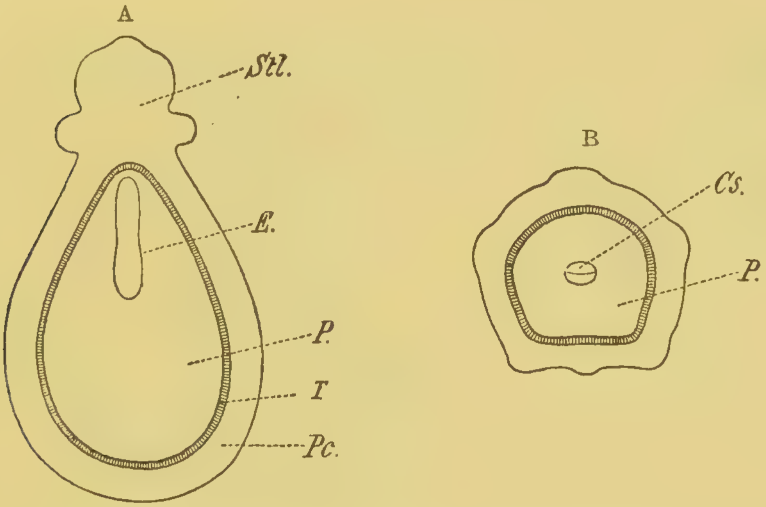

FIG. 411.—*Ptychotis Ajowan*, × 24. A, longitudinal section of fruit: *Pc*, pericarp; *T*, testa; *P*, endosperm; *E*, embryo; *Stl*, stylopodium. B, transverse section of fruit: *P*, endosperm; *Cs*, cotyledons.

Seedling (fig. 412).

Primary root small, colourless unbranched (at first).

Hypocotyl herbaceous, 3–4 cm. long, less than 1 mm. thick, glabrous, pale green.

Cotyledons 2·25 cm. long including the petiole; 2–2·5 mm. wide, lanceolate, tapering at the base, subacute at the apex, entire, with obscure midrib, glabrous, thin, light green; petiole long and slender.

Stem very short, glabrous, light green; 1st internode 3–4 mm. long, ·75 mm. thick.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, ultimately ternately or pinnately multisect, with acute segments, glabrous, light green; petioles semiterete, channelled above, glabrous.

No. 1. With a glabrous petiole 3·5 cm. long, ·75 mm. thick, and a ternatisect lamina 1 cm. long and as wide, obscurely nerved, glabrous.

No. 2. Ternatisect. Both are frequently much simpler than in the accompanying sketch.

No. 3. Pinnately multisect; pinnæ cuneately palmate, bi–tri-sect with subulate or linear-subulate, acute or minutely apiculate segments.

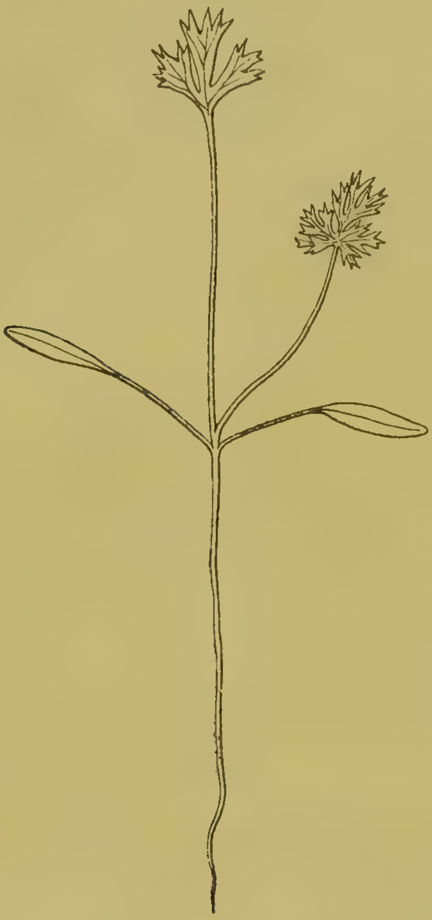

FIG. 412.—*Ptychotis Ajowan*. Nat. size.

Scandix Pecten-Veneris, *L.*

Primary root long, tapering downwards, with slender, secondary rootlets.

Hypocotyl tapering insensibly into the root.

Cotyledons linear, obtuse, entire, tipped with a mucro, tapering gradually into the petiole, glabrous, shallowly grooved above, showing a distinct midrib on the under side, but no other discernible venation when fresh, but after a time slender alternate nerves; 6·4–6·8 cm. long, including the petiole, 1·5–2 mm. wide about the middle of the lamina which tapers to both ends, but more especially the lower; petiole shallowly grooved above, dilated and connate at the base, forming a short sheath or cup around the plumule, and split a little more deeply on one side.

Stem herbaceous, erect, annual, produced only when about to flower; primary internodes undeveloped.

Leaves pinnately multisect, radical and cauline, alternate, exstipulate, petiolate, minutely pubescent or scaberulous at the edges of the segments, otherwise glabrous, deep green above, paler beneath, with a multifid branching venation corresponding to the segments into each of which a nerve runs; primary nerves opposite, secondary and higher ones alternate; petioles semiterete, channelled above, tapering somewhat upwards, dilated and sheathing at the base, minutely pubescent at the margins of the groove.

No. 1. Ovate-triangular in outline, tripinnatisect with small subulate or lanceolate, cuspidate segments.

No. 2. Triangular in outline, three to four times pinnatisect, with very small subulate or lanceolate, acute, segments.

Fœniculum vulgare, *Gaertn.* (fig. 413).

Primary root long, tapering downwards and giving off lateral fibres, colourless.

Hypocotyl undeveloped, or subterranean and indistinguishable from the root.

Cotyledons linear, obtuse, entire, petiolate, deep green, glabrous, with inconspicuous or indiscernible venation; lamina hardly broader than the petiole, and tapering insensibly into it, and together with the petiole 3–3·5 cm. long; petioles flattened or shallowly grooved above, dilated, and connate at the base forming a sheath or cup around the plumule, covered with earth at the base.

Stem herbaceous, forming a perennial rootstock, and throwing up annual flowering stems; primary internodes undeveloped.

Leaves simple, pinnately multisect, radical and cauline, alternate, exstipulate, petiolate, glabrous, deep glaucous-green, with primary, secondary, tertiary, and quaternary, alternate, ascending nerves; petioles much dilated and sheathing at the base, glabrous, deep glaucous-green; first one channelled above; second terete and slightly channelled towards the apex, substriate.

No. 1. Triangular, acute, bipinnatisect with linear acute segments, generally widest about the middle.

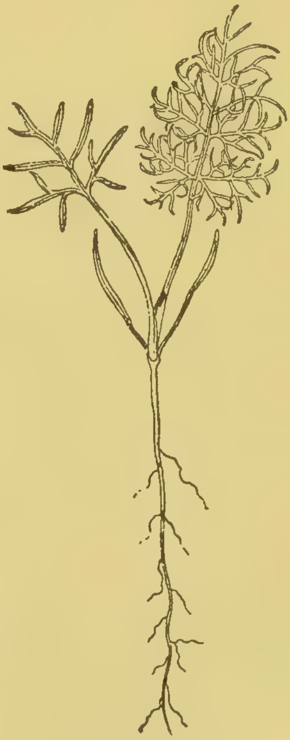

FIG. 413.
Fœniculum vulgare
Half nat. size.

No. 2. Three to four times pinnatisect, with slender, linear, acute segments.

Aciphylla squarrosa, *Forst.* (fig. 414).

Hypocotyl subterranean.

Cotyledons linear, acute, coriaceous, flattened above, convex on the back, glabrous, lucid, dilated and sheathing at the base, pale green, 3·6–4·3 cm. long, 1 mm. wide.

Stem not elongating till about to flower.

Leaves simple, entire in the first few of the seedling, ultimately bipinnatisect, glabrous, radical, alternate, exstipulate, sessile, scabrous at the margins and densely dotted with sunken glands, green or glaucous, rigid with divaricate spiny-tipped segments.

Nos. 1–3. Linear, spiny-tipped, entire.

No. 4. With one lateral segment.

No. 5. With two lateral segments ; all linear.

Nos. 6–9. Linear, entire ; but individual seedlings vary to some extent.

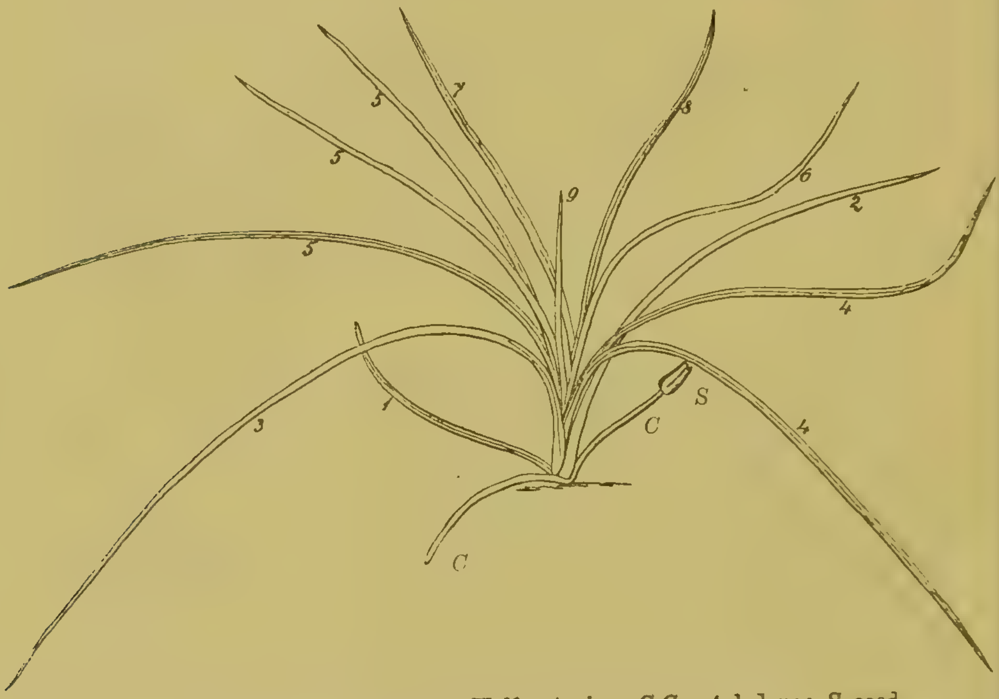

Fig. 414.—*Aciphylla squarrosa.* **Half nat. size.** *C C*, **cotyledons ;** *S*, **seed.**

Ferula communis, *L.*

Primary root long, tapering downwards, stout and furnished with lateral rootlets.

Hypocotyl short, subterranean or undeveloped, or indistinguishable from the root.

Cotyledons linear, obtuse, with long petioles, tapering slightly to an obtuse point and gradually into the petiole, appearing trinerved from the union of two to three alternate nerves on each side of and parallel with the midrib, glabrous and shining on both surfaces, deep green above, paler beneath ; lamina 2·7–4·5 cm. long, 4·5 5·5 mm. wide ; petiole 3·4–4·4 cm. long, plano-convex, dilated at the base, connate and sheathing the plumule for 7–8·5 mm. at the base, and often splitting there on one side.

Stem herbaceous, forming a perennial rootstock, and sending up annual flowering stems; primary internodes undeveloped.

Leaves pinnately multisect, chiefly radical, the cauline smaller, alternate, exstipulate, petiolate, with a venation corresponding to the divisions of the leaf, each segment of which has a primary nerve, glabrous, shining on both surfaces, deep green above, paler beneath; petiole subterete, or laterally compressed, shallowly channelled above, thicker dorso-ventrally than in the other direction, glabrous, covered with a glaucous bloom, striated longitudinally, dilated and sheathing at the base.

No. 1. Pinnately tri- or slightly quadri-sect with the ultimate divisions subulate or linear, acute, with colourless tips.

Ferula fœtida, *Bunge*.

Primary root as in last species.

Hypocotyl undeveloped.

Cotyledons linear-lanceolate, obtuse, entire, gradually tapering into the long petiole, glabrous, shining on both surfaces, deep green above, paler beneath, with a distinct midrib but no other discernible venation in the fresh state, about 14 cm. long including the petiole, and 6 mm. wide about the middle of the lamina; petioles semiterete, flattened above, with obtuse edges connate for 8–10 mm. at the base, forming a sheath around the plumule and afterwards splitting on one side, glabrous, green, stained with red.

Stem herbaceous, perennial, developing in length only when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved, reticulate, glabrous except the petioles, deep green above, paler beneath, shining on both surfaces; petiole subterete, slightly flattened on the upper side, or subchannelled towards the apex, dilated and sheathing at the base, minutely and thinly pubescent, at least in the young state.

No. 1. Triangular, tripartite, with a long petiole; terminal lobe rhomboid-cuneate, trifid and serrate above the middle or towards the apex; lateral lobes spathulate-cuneate, serrate towards the apex.

No. 2. Similar, but having the lateral lobes broader and somewhat bifid.

Peucedanum sativum, *L.*

Primary root fleshy, or stout, tapering, colourless, with lateral fibres.

Hypocotyl very short or indistinguishable from the radicle.

Cotyledons linear or oblong-linear, obtuse, entire, with a strong midrib, and alternate, lateral, ascending nerves, reticulate, petiolate, and tapering into the petiole, glabrous; lamina 1·5–1·8 cm. long, 3·5–5 mm. wide; petiole flattened above, or shallowly grooved, convex on the back, dilated at the base and perfoliate, glabrous, 4·5–11 mm. long. Individuals occur very frequently in which one or both (fig. 415) of the cotyledons are bifid, bipartite, or divided to the base, appearing in the last case double, that is, simulating three or four cotyledons, instead of two. Where fission occurs there is a distinct midrib to each lobe of the cotyledon.

Stem elongated the second season when about to flower.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous or variously pubescent or hairy in wild plants; petioles more than half terete, narrowly and shallowly grooved above, glabrous or hairy, green or stained with purple, much dilated and sheathing at the base, striated with slender ridges.

No. 1. Cordate, obtuse, palmately five-nerved, obtusely crenate-dentate.

No. 2. Similar but trilobulate, and with overlapping auricles at the base.

Ultimate leaves pinnatisect; lateral lobes or segments cordate- or oblong-cordate, obtuse, with overlapping auricles at the base covering the primary midrib, alternately and ascendingly penninerved, lobulate, obtusely and cuspidately serrate-dentate, subreticulate, especially on the under surface.

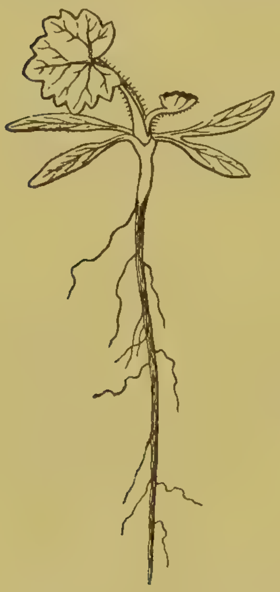

FIG. 415.
Peucedanum sativum.
Nat. size.

Heracleum Sprengelianum, *Wight et Arn.*

Hypocotyl subterranean, or 4–6 mm. exposed.

Cotyledons oblong, oval, or elliptic, entire, obtuse, 1·7–1·9 cm. long, 8–10 mm. wide, three- to five-nerved, glabrous, pale green, shining; petiole 1–2·2 cm. long, 1–2 mm. wide, flattened or subchannelled above, convex beneath, glabrous.

Leaves radical, alternate, petiolate; petiole dilated and sheathing at the base.

No. 1. Cordate, obtuse, shallowly five-lobed, obtusely dentate or crenate, with mucro-tipped crenatures, palmately five-nerved (in small or weakly seedlings tri-lobed and -nerved), pale green above and coarsely hairy, paler and almost villous beneath, ultimately pubescent on both surfaces; petiole subterete, shallowly channelled on the upper side, pale green and subvillous on the upper half, reddish and coarsely hairy on the lower, long, but length variable.

Intermediate forms are trifid, tripartite or trisect, with lobulate and dentate-serrate divisions. Further developed leaves are triangular, acute, pinnatisect and deeply pinnatifid; primary divisions triangular, acute, deeply pinnatifid and lobulate, dentate-serrate; terminal division broadly triangular, acute, deeply tripartite, lobulate and dentate-serrate.

Heracleum villosum, *Fisch.* (fig. 416).

Primary root stout, fleshy, tapering downwards and giving rise to short lateral fibrils, biennial.

Hypocotyl stout, fleshy, merging into the root.

Cotyledons sometimes rather unequal, linear-oblong, obtuse, tapering into the petiole, which is dilated and sheathing at the base, channelled above, glabrous, 2·6–3·9 cm. long, 5 mm. at the widest.

Stem herbaceous, undeveloped till it flowers.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, hispid, glandular and odorous; petiole channelled above, convex and ridged beneath, coarsely hairy, reddish at the base and pale green upwards, much dilated and sheathing at the base.

No. 1. Rotund-cordate, obtuse, palmately five-nerved, rather deeply crenate; crenatures mucronate.

No. 2. Palmately five-nerved, trilobed, cordate at the base, dentate-serrate with acute or mucronate serratures.

Intermediate forms are first triangular, trilobed, cordate at the base, and dentate-serrate.

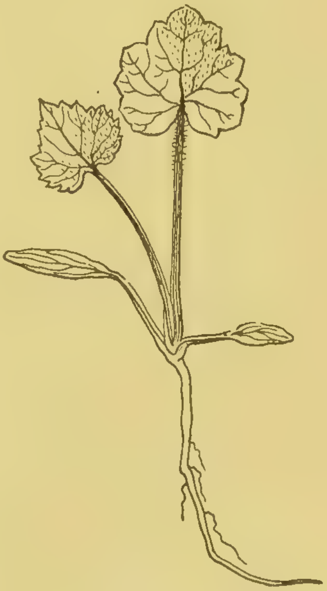

Fig. 416.—*Heracleum villosum.* Half nat. size.

Another stage in advance would be tripartite; lateral segments ovate, irregularly dentate-serrate; terminal lobe trifid and dentate-serrate.

Ultimate leaves pinnatipartite and deeply pinnatifid in the lower half, and deeply pinnatifid or bipinnatifid in the upper, shortly pubescent on both sides ; ultimate lobes ovate or oblong-ovate, acuminate, irregularly dentate.

ARALIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 931.

Fruit and Seed.—In the last Order the ovary was in all cases bicarpellary, and always two-celled except where the dissepiment ultimately became lost or aborted. The ovary in this case is also inferior, but possesses from two to many cells and as many carpels. In a few cases the number is reduced to one. The ovules are solitary in each cell, suspended from the apex of the cavity, and anatropous, with the raphe usually, if not always, ventral. The fruit is baccate or often drupaceous, with a fleshy, or rarely membranous exocarp. The endocarp is woody, crustaceous or cartilaginous, rarely membranous, and whatever the number of carpels making up the ovary, the endocarp of each is separately lignified, so that the fruit can be broken up into as many pieces as there were carpels. In multicarpellary fruits the seeds are more or less compressed laterally or subtriquetrous owing to the mutual pressure of the carpels to the interior of which they conform. The testa is always thin and membranous, and often closely applied or adnate to the endosperm which is copious and fleshy or cartilaginous, sometimes ruminated as in Hedera. The embryo is always minute and embedded in the endosperm close to the hilum ; the cotyledons are rounded, ovate or oblong, and generally about the same breadth as the radicle.

Amongst the more exceptional cases in the Order are Cuphocarpus and Arthrophyllum with ovaries consisting of a single carpel, and Tupidanthus with nearly one hundred carpels. The fruit of Horsfieldia when mature separates into as many pieces as there are component carpels, and the parts of the fruit in several other genera are readily separable.

Seedlings.—The cotyledons amongst the few seedlings observed in this Order are ovate, petiolate and distinctly or indistinctly trinerved. Those of Aralia edulis (fig. 417) are minutely but distinctly mucronate. The first leaf is reniform-cordate and serrate, followed by at least two others which are cordate and acuminate. The ultimate leaves are very large and bipinnate with serrate leaflets. The first two leaves of Hedera Helix (fig. 418) are trifid and palmately five-nerved, with the basal pair very slender. The next two give an indication of five lobes. The cotyledons are coriaceous, entire, and very persistent. The leaves of the first year's growth of H. palmata in the specimen noted by us differed from those of the type in the first one being reduced to a petiole (possibly accidental). The second showed an indication of five lobes; the third was small and terminated the first year's growth; the fourth and fifth were palmately five-lobed, very similar to those of the adult. A slight variation is shown by Tupidanthus calyptratus inasmuch as the cotyledons are relatively broader and distinctly emarginate. The first leaf is ovate, acute, tridentate and trinerved.

Aralia edulis, *Sieb. et Zucc.* (fig. 417).

Primary root tapering, flexuose, colourless, giving off a few lateral rootlets.

Hypocotyl erect, terete, glabrous, pale green, suffused with purple, 6 mm. long.

Cotyledons ovate, obtuse, mucronate, petiolate, glabrous, trinerved, subreticulate, lucid; lamina 8 mm. long, 6 mm. wide; petiole 3·5 mm. long.

Stem herbaceous, annually dying down to the rootstock.

Leaves compound (seedling or primary ones simple), radical and cauline, alternate, exstipulate, petiolate, thinly hairy on the nerves beneath, also pubescent above when young, deep green above, paler beneath, shining on both surfaces; petioles semiterete, deeply channelled above, slightly hairy, dilated and sheathing at the base; sheaths somewhat laciniate.

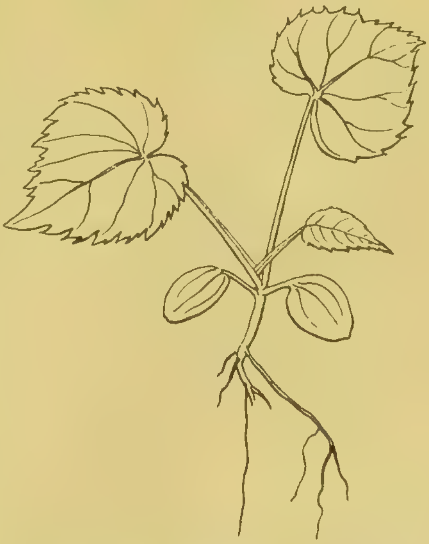

FIG. 417.—*Aralia edulis.* Nat. size.

No. 1. Cordate-reniform, acute, acutely and irregularly serrate, five-nerved.

No. 2. Cordate, acute, seven-nerved, irregularly and acutely serrate.

No. 3. Cordate, acuminate, seven-nerved, irregularly and acutely serrate.

Hedera Helix, *L.*, *var.* palmata.

Primary root tapering, flexuose, giving off numerous lateral, flexuose fibres.

Hypocotyl subflexuose, terete, glabrous, subverrucose, brownish, 2·2 cm. long, woody.

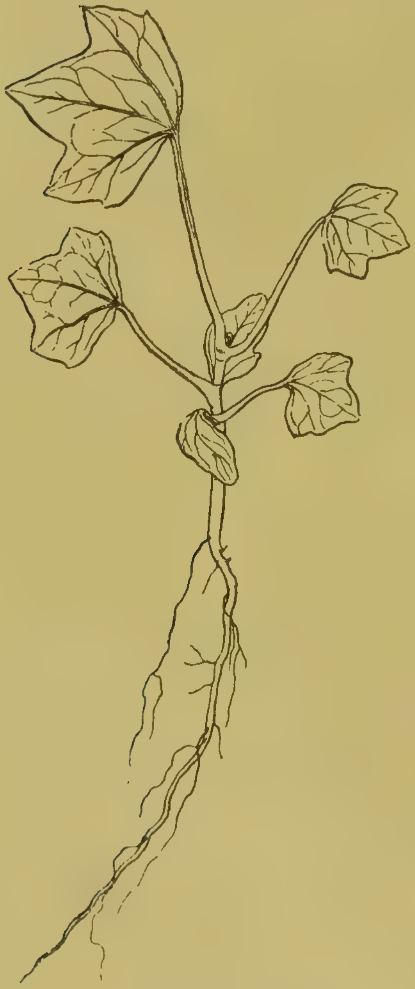

Fig. 418.—*Hedera Helix.* Half nat. size.

Cotyledons oval, obtuse, petiolate, subtrinerved and reticulate, foliaceous, deep green above, paler beneath, glabrous; petiole flattened above with a longitudinal median ridge, 6 mm. long.

Stem woody, terete, zigzag or subflexuose, pubescent with stellately branching hairs, pale green; 1st internode 1 mm. long; 2nd 5 mm.; 3rd 3 mm.; 4th 9 mm.; 5th 12 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate (petiole with sheathing base), evergreen, pubescent with stellately branching hairs when young and unfolding, glabrescent when old except for a few hairs on the nerves, deep green above, reticulate, paler beneath.

No. 1. Reduced to a petiole, or limb, small.

No. 2. Palmately tri-fid and -nerved with a lateral tooth on each side foreshadowing two other lobes; lobes and teeth obtuse, mucronate.

No. 3. Very small, trifid.

No. 4. Palmately five-nerved and -lobed, subcuneate at the base; lower nerve on each side slender and supported by a large lateral branch from the nerves above; two lateral lobes small, triangular; three middle lobes triangular-elongate, subacute or mucronate.

No. 5. Similar to No. 4, but not yet developed.

This variety differs from the type, Hedera Helix (fig. 418), in the fourth leaf, in the narrower and more elongated lobes, and the nerves ascending at a more acute angle.

Tupidanthus calyptratus, *Hook. f. et Thoms.*

Hypocotyl erect, thickest near the soil, square, glabrous, 3·5–4·5 cm. long, light green or almost colourless.

Cotyledons ovate-oblong, obtuse, emarginate, with short petioles, glabrous, light green, distinctly trinerved, like the foliage leaves.

Stem with primary internodes undeveloped.

First leaf simple, tridentate, cauline, alternate, exstipulate, petiolate, ovate, acute, glabrous, subshiny green, trinerved ; petiole comparatively long, channelled on the upper side.

CORNACEÆ.

Benth. et Hook. *Gen. Pl.* i. 947.

Fruit and Seed.—As in the two preceding Orders, the ovary here also is inferior. It has from one to four cells, with a solitary anatropous ovule in each, suspended from the top of the cavity, except in Garrya where there are two ovules in the one-celled ovary which is formed from two carpels. The raphe is lateral or dorsal, and the membranous testa is confluent with, or inseparable from the endosperm. The fruit is most often drupaceous with a fleshy or pulpy exocarp and a one- to four-celled woody endocarp, more rarely separable into two bony or crustaceous one-seeded pieces. The seed is large, oblong, or elongated cylindrical, sometimes compressed as in Marlea, ovoid as in Aucuba, or linear as in Toricellia. Endosperm is copious and fleshy ; in Alangium it is ruminate. The embryo is comparatively large, cylindrical, and nearly as long as the endosperm, or the cotyledons are much wider, in some cases about equal to the width of the endosperm ; it is fleshy in Kaliphora, but minute in Griselinia, Aucuba and Toricellia. The radicle is superior and terete when elongated.

Cornus alba is a fairly representative type. The oval cotyledons are trinerved and opposite, but sometimes oblique and slightly shorter than the terete radicle. One of the two cells of the ovary is generally aborted while the greater part of the drupaceous fruit is occupied by one large seed. The ovary and fruit of Aucuba japonica are one-celled, and the latter contains a very large ovoid seed enclosing a minute embryo close to the upper end of the endosperm. The blunt radicle constitutes by far the larger part of the embryo and is much wider than the cotyledons. The latter are narrowly oblong in Curtisia, linear in Corokia, foliaceous, twisted and plicate in Alangium.

Seedlings.—Few of the members of this Order are often grown from seed, with exception of Cornus, Aucuba, Griselinia, Garrya and Corokia, and but a few species even of these. Seedlings are still less common. The seedlings of Aucuba japonica (fig. 419) are large and vigorous notwithstanding the diminutive size of the embryo while in the seed. This is to be accounted for by the large quantity of endosperm available during germination. The hypocotyl is very stout and elongated; and the cotyledons are ovate, obtuse, three- to five-nerved and entire. They seem to be exceeded in size by those of the variety named A. j. ilicifolia, which sometimes attain a length of 3·5 cm., and a breadth of 2·1 cm. The first two pairs of leaves are opposite, and ovate, with a few coarse teeth. The seedling of A. japonica observed produced only one pair of leaves and went to rest with its bud covered by two pairs of

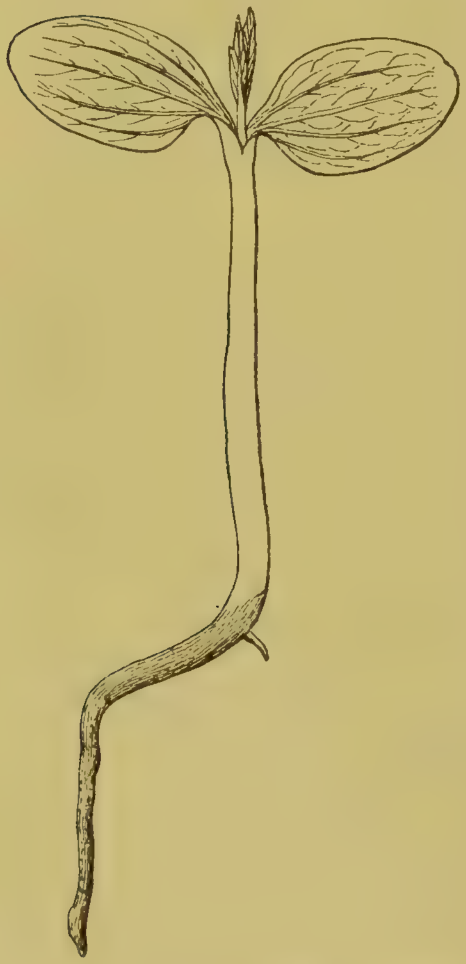

Fig. 419.—*Aucuba japonica.* Nat. size.

leaves reduced to scales. After a short time the latter dropped, and growth was resumed.

Aucuba japonica, *Thunb.* (fig. 419).

Primary root stout, fleshy, subflexuose, ultimately producing strong, fleshy lateral roots also subflexuose.

Hypocotyl woody, erect, terete, glabrous, pale green, about 3 cm. long.

Cotyledons oblong-ovate, obtuse, three- or sub-five-nerved, shortly petiolate ; lamina 2·15 cm. long, 1–1·4 cm. wide.

Stem woody, erect, terete, glabrous, hairy when young, pale green ; 1st internode 1·35 cm. long ; 2nd 1 mm. ; 3rd 5·5 mm. ; 4th 1·05 cm.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate, glabrous, bright green and shining above, paler beneath, marked on both surfaces with yellow or creamy yellow blotches ; petioles semi-terete, channelled above in seedling plants, flattened in the adult, pale green or purplish.

First pair ovate, acute, serrate-dentate with about two teeth on each side.

Growth stopped here, and recommenced after a time.

Second and third pairs reduced to small ovate-subulate, acute, deciduous or caducous scales, decussating with the normal-sized leaves.

Fourth pair oblong-lanceolate, acute with about two teeth on each side.

Ultimate leaves large, lanceolate-oblong, gradually narrowed to an obtuse point and cuspidate, distantly serrate-dentate on the upper half, alternately penninerved, rather obscurely reticulate.

CAPRIFOLIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1.

Fruit and Seed.—The ovary in this Order is inferior and consists of two to six carpels, most frequently three, and as many cells, except in the case of Viburnum which has only one cell or is spuriously two- to three-celled. Here as in other cases there is evidence of a reduction of the original number of perfect cells. The ovules are usually solitary, and suspended from the apex of each cell or they are numerous and inserted on the inner angles of the cells as in Leycesteria and Diervilla, and anatropous with a dorsal or lateral raphe. The fruit is variable in different genera and either baccate, drupaceous, or dry and indehiscent, or capsular. In several species of Lonicera the baccate fruits are united laterally in pairs. When mature the number of cells is the same as in the ovary, or may be reduced to one by the breaking up of the septa; each cell is one- to many-seeded. In some genera the fruit is in a transition state, as the seeds in some of the cells become aborted when quite young; in some cases some of the cells contain only one seed, while other cells of the same fruit have many seeds. When the seeds are solitary they are generally large and conform to the shape of the cell; but when numerous they are small and subglobular or variously angled. The endocarp is sometimes leathery or subwoody in baccate fruits, and the testa membranous, as in Viburnum, or the testa may be leathery, crustaceous or spongy, or winged along one side. Endosperm is copious and fleshy. The embryo is generally very small, and embedded in the endosperm close to the hilum, or it may elongate till it nearly equals the endosperm in length, with ovate or oblong cotyledons and an elongated terete radicle.

The last case is illustrated by Sambucus nigra, the fruit of which is baccate and three-celled, with the endocarp of each carpel forming a long thick layer enclosing and protecting a solitary, oblong seed, with a very thin testa and a lateral raphe.

The fruits of Viburnum are baccate or dry and indehiscent, globose or variously compressed or terete, and one- or spuriously three-celled. The endocarp is leathery or bony; and the solitary seed varies greatly in shape; the testa is membranous, the raphe lateral, and the embryo minute. They may be divided into three groups, the first of which is typified by V. Opulus. Although the fruit is globose, the endocarp and seed are much compressed. In a few exceptional cases the fruit is bluntly trigonous with a rather sharply trigonous endocarp and seed, pointing to the ancestral condition of the tricarpellary ovary.

In the young fruit the endocarp and seed seem to be generally slightly trigonous. The lateral raphe (see p. 50) almost entirely encompasses the seeds, a very exceptional case in any Natural Order of Phanerogams. The cell of the young ovary greatly exceeds the ovule in size; and the latter hangs suspended from the top of the cavity with the raphe already passing along one side, across the end and partly up the opposite side to the chalaza. The ultimate condition of the raphe seems to be due to a localisation of growth in the lower part of the seed; so that while the latter is making an effort to occupy the cell which it ultimately completely fills, the chalaza and that part of the seed above it remain stationary, while the lower part lengthens. The raphe in fact does not creep round the edge of the seed, but its great length is due to the inequality of growth in the upper and lower halves. The endocarp and seed of V. Lantana and V. Lentago (fig. 423) agree with those of V. Opulus in all main particulars, but the fruits are much compressed. The seed of V. Lantana is suborbicular and dorso-ventrally much compressed; that of V. Lentago is more oblong and as much compressed except at the apex, where there is a short ridge or elevation, opposite which is the embryo, and the seed conforms to it at that point. The raphe here is even more extraordinary, for it encircles the seed almost back again to the hilum.

The second group is typified by V. dentatum (fig. 421), the seed of which is ovoid or subglobose, ridged on both sides at the top as in V. Lentago, but strongly inflexed at the sides, making it rather deeply concave on one side. This it does in conformity with the cavity of the endocarp, which indicates an ancestral three-celled condition of the ovary. The raphe almost completely encircles the seed, and is not strictly marginal except at the lower end. Elsewhere it is irregular and undulatory at some distance from the margin. The ovule and young seed behave in a similar manner to those of V. Opulus. The fruit, endocarp and seed of V. montanum (fig. 425) are very much like those of V. dentatum. The raphe differs chiefly in being distant from the much incurved edge of the seed at the lower end. The third group is represented by V. lantanoides (fig. 424).

The fruit is oblong-oval in outline, somewhat compressed, ridged at the top, and longitudinally furrowed on both sides. A transverse section shows that the endocarp, and seed are infolded at the sides. The raphe touches the edge of the seed at the lower end only. The strongest character of this type is the ruminated endosperm.

The ovary of Symphoricarpus racemosus is four-celled, and contains four to five ovules in each of two cells, with one in each of the other two. The latter only mature into perfect seeds, having a bony, white testa with a membranous inner layer. The endosperm is fissured or slightly hollow along the centre, and the embryo is minute with ovate-oblong cotyledons. The fruit is globose and baccate as in Lonicera Periclymenum; in the latter, although originally three-celled, it becomes one-celled by the destruction of the septa and contains few seeds. These are oblong, subcompressed and biconvex, with a crustaceous testa. The embryo is small, with oblong or ovate cotyledons.

Seedlings.—The cotyledons of the different species of this family observed attain a considerable size during and after germination, depending doubtless in a great measure upon the size and shape of the seed, together with the quantity of reserve-material. There is comparatively little variation amongst them, and typically they may be described as oblong, obtuse, entire, or incipiently emarginate, petiolate with two to three pairs of nerves arising from different points of the midrib, running longitudinally along the lamina, and some of them again as a rule uniting with the midrib below the apex. The petioles are slightly connate at the base. A good representative type is furnished by Sambucus nigra (fig. 420) having oblong-ovate cotyledons. An interesting case of evolution is shown by the primary leaves of the seedling. They are opposite, and the two first pairs are cordate, serrate, and simple. Those of the third pair are pinnately trifoliolate with broadly ovate leaflets. The cotyledons of Viburnum punctatum (fig. 426) differ chiefly from those of Sambucus nigra in being seven-nerved. The leaves are all simple, opposite and decussate, with the first pair ovate-elliptic and bluntly serrate. The succeeding five pairs are more decidedly elliptic. The cotyledons of Triosteum pinnatifidum are broadly oblong and trinerved, with the petioles connate, so as to form a short tube around the axis. The leaves are dimorphic. The two first pairs are lanceolate, while those produced on the seedling when growth is resumed the following spring are broader and lanceolate-elliptic, while others are rhomboid and deeply trilobed on one side only, with rounded sinuses, ovate lateral lobes and broadly triangular terminal ones. The cotyledons of Lonicera Munroi (fig. 427) are oblong-oval, with two pairs of lateral incurved nerves arising at different levels on the midrib. The first four pairs of leaves are broadly oval, entire, and suddenly cuneate at the base. The cotyledons of Viburnum Opulus (fig. 422) differ from any of the above in being oblong, relatively longer, narrower and sessile. They have two pairs of lateral nerves with a considerable interval between them, and they suddenly taper to a connate base. The first pair of leaves are ovate with two pairs of coarse lateral teeth or lobes each with a strong nerve, arising alternately from the midrib. The seedlings took nearly seven months to germinate in a greenhouse temperature, from the 9th of October to the 1st of May following. The leathery or subwoody endocarp splits along the edges for the lower half of its length in order to favour the exit of the cotyledons.

Sambucus nigra, *L.*

Ovary of two to five, usually three, carpels, two- to five-, usually three-celled, each cell one-ovuled; ovules pendulous, anatropous; micropyle superior.

Fruit baccate, globose, glabrous, tipped with the persistent lobes of the calyx, two- to five-, usually three-seeded; epicarp thin; mesocarp pulpy or juicy; endocarp bony, whitish, acting as a protection to the seed.

Seed narrowly oblong, obtuse at either end, conforming rather closely to the interior of the bony endocarp; testa very thin, membranous; raphe lateral, forming a ridge on the testa; micropyle and hilum basal at the upper end of the seed chalaza apical, at the lower end of the seed.

Endosperm copious, fleshy, transparent, white.

Embryo straight, narrow, central, nearly as long as the endosperm, colourless; cotyledons oblong, obtuse, entire, many times shorter and slightly broader than the radicle; radicle cylindrical, obtuse, slightly narrower in the middle or at the end next the cotyledons, with its tip close to the micropyle, but within the endosperm.

Seedling (fig. 420).

Primary root slender, tapering, with a few fibrous lateral rootlets.

Hypocotyl tender, succulent, glabrous, or with a few short papillose hairs, erect, terete, pale green, 2·5 cm. long, 1 mm. thick.

Cotyledons foliaceous, glabrous; lamina oblong-ovate, obtuse, subcuneate at the base, bright green above, paler beneath, 1·5 cm. long, 8 mm. wide; petiole channelled above, connate around the stem at the base.

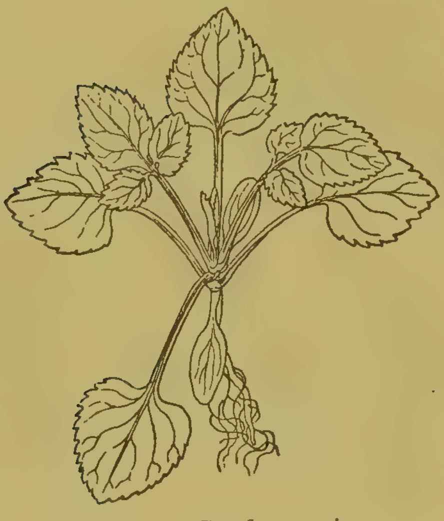

FIG. 420.—*Sambucus nigra.* Half nat. size.

Stem erect, terete, glabrous, green, succulent in the seedling stage, ultimately woody; 1st internode 2 mm. long, or hardly developed, and several succeeding ones similar.

Leaves simple (ultimately imparipinnate), cauline, opposite, stipulate; petiole subterete, channelled above.

First pair cordate, acute, acutely serrate, with five to seven ascending and incurved nerves, thinly pubescent in the young state.

Second pair similar.

Third pair pinnately trifoliolate; leaflets broadly ovate, acute, acutely serrate; terminal leaflet much the largest.

Viburnum, *L.*

EARLY DEVELOPMENT OF FRUIT AND SEED (fig. 421).

The position of the raphe in this genus is interesting and peculiar.

At the time of flowering or immediately after the corolla has dropped, it passes (fig. 421, A) along one side of the ovule, across the lower and apical end, and a little way up the other side to the chalaza, which at this time is a little below the middle of the ovule.

Owing to a localisation of growth in the young seed, the lower and apical end including the raphe attains (fig. 421, B, C) great development. The seed being attached at the apex of the cell, is encouraged to grow at its lower end only, in order to completely occupy the cavity of the ovary. The distance between the chalaza and the hilum or micropyle remains unaltered, consequently as growth goes on the raphe seems to creep farther and farther round the seed, whereas it is only the lower part of the seed and the raphe which grow and develop together till the cavity of the ovary is completely filled, when the raphe surrounds nearly the whole of the mature seed.

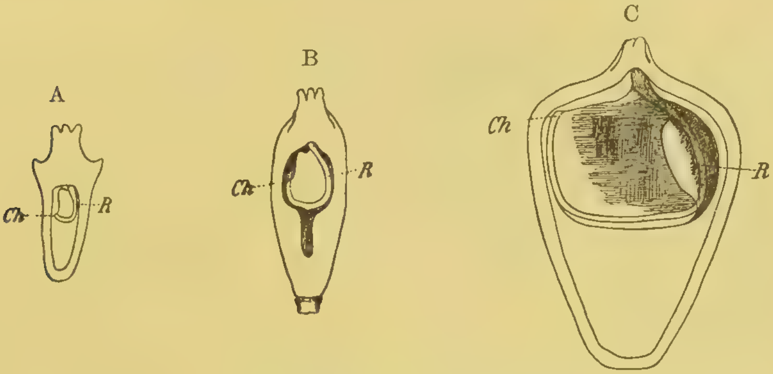

FIG. 421.—*Viburnum dentatum.* A, B, and C, longitudinal sections of the fruit in three stages, × 5 : *R*, raphe; *Ch*, chalaza.

Viburnum Opulus, *L.*

Ovary of three carpels, one-celled, one-ovuled; ovule pendulous from the top of the inner angle of the cell, anatropous; micropyle superior.

Fruit a globose drupe, red when mature; mesocarp pulpy; endocarp horny.

Seed ovate-rotund, cuspidate at the apex, shallowly emarginate at the base, much compressed or flattened laterally, conforming to the interior of the endocarp, brownish-red, with a thin adherent testa; raphe lateral, passing along the edge of the seed, round the base and half way up the other side; hilum and micropyle superior, forming the cuspidate tip of the seed; chalaza about the middle of one edge.

Endosperm in the mature seed abundant, horny, white.

Embryo small, straight, embedded in the endosperm close to the hilum; cotyledons spathulate-oblong, obtuse, entire, about as long as the stout, obtuse radicle, and slightly broader than it, with their backs to the placenta in the broader plane of the seed.

EARLY DEVELOPMENT OF FRUIT AND SEED.

Fruits frequently occur that are obtusely trigonous, indicating the ancestral form of the tricarpellary ovary, while in the young condition the cavity of the ovary is perhaps always slightly trigonous.

When the fruit has grown to some size, but long before maturity, the young growing seed is rotund-obovate or almost orbicular and very much shorter than the cell which it occupies.

The raphe at this stage passes round one side, along the apex, and a short way up the other side of the seed.

Further growth proceeds below the chalaza; the raphe also keeps pace with this localised growth and consequently attains its great length, nearly surrounding the margins of the flattened seed.

When the seed has attained full size, it is orbicular, or nearly so, biconvex or lenticular, and much compressed dorso-ventrally, rather acutely two-edged, and completely fills the cavity of the ovary; the raphe encompasses all but a short part of the edge, corresponding to the part above it in the ovule or exceeding it but a very little.

Seedling (fig. 422).

Hypocotyl erect, terete, glabrous, reddish, stout at the base and tapering upwards, 1–1·5 cm. above the soil.

Cotyledons oblong, obtuse or submucronate, entire, sessile, deep shining green, glabrous, tapering to the base and connate, trinerved at the base, with the nerves incurved about or below the middle, and uniting with other two that run nearly parallel with the midrib and margin, becoming incurved and uniting with the midrib close to the apex, slightly reticulate, 9–12 mm. long, 3–4 mm. wide.

Stem erect, two-angled in the earliest seedling form with the angles running down from the edges of the pair of leaves next above them, ultimately four- or many-angled or ridged and furrowed, glabrous, pale green, ultimately shrubby; 1st internode 6–15 mm. long.

Leaves simple, cauline, opposite, first few pairs exstipulate, ciliate, pubescent beneath, at least when young (first pair ciliate only), strongly palmately trinerved and lobate, coarsely, acutely and irregularly dentate, with the principal nerves again strongly alternately nerved and reticulate, deep green above, paler and shining beneath; petioles semiterete, deeply channelled above, dilated at the base, amplexicaul and connate, thinly pubescent in the young state, glabrescent, furnished at the margins in the upper part with large, stipitate or sessile, green glands; stipules forming one to two linear, obtuse, or acute processes seated on the margin of the petiole and near its base, green, glabrous.

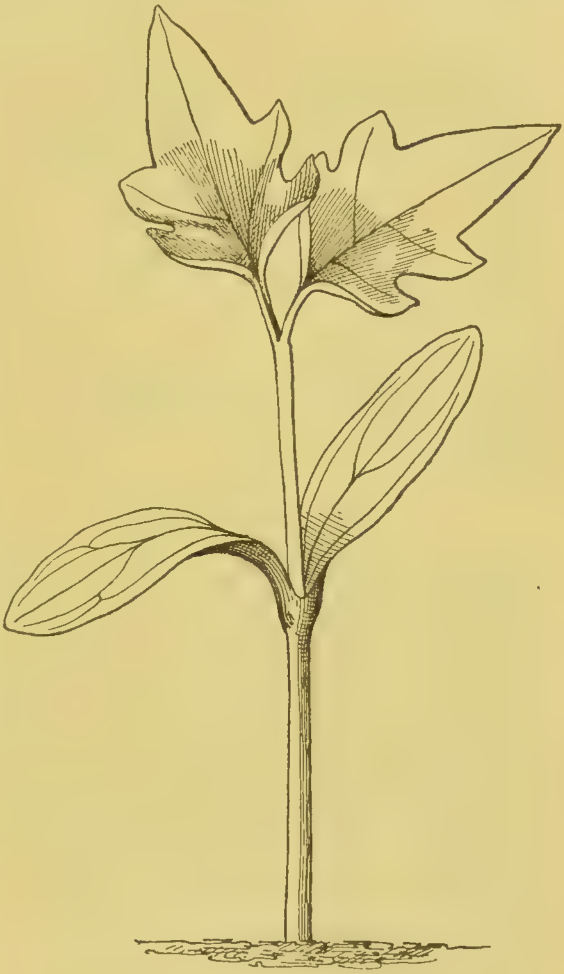
FIG. 422.—*Viburnum Opulus*, × 2.

First pair of leaves ovate, acute, trilobed, with two large teeth near the base, alternately and ascendingly penninerved, with a strong nerve running into each lobe or tooth, ciliate, otherwise glabrous, light green and shining on both surfaces, exstipulate, with short red margined petioles.

Ultimate leaves palmately tri-nerved and -lobed, with the three principal nerves again strongly and ascendingly penninerved, reticulate; lobes acute, coarsely and irregularly dentate, with deltoid acute teeth; middle lobe the largest and on strong growing shoots often trifid.

Viburnum Lentago, *L.* (fig. 423).

Fruit a drupe, globose or oblong, slightly compressed dorso-ventrally, glabrous, black; mesocarp pulpy, very dark-coloured; endocarp thick, tough, horny, separable into halves longitudinally along the edges, very much compressed dorso-ventrally, rounded at its lower end, cuspidate at the apex.

Seed orbicular or oblong, rounded at the lower end, but sometimes emarginate owing to a small indentation or inflection of the endocarp to which it conforms, cuspidate at the apex where the radicle lies; testa thin, membranous, minutely alveolate or honeycombed over great part of its surface, deep brown; hilum and micropyle contiguous, superior, or basal to the seed; raphe commencing at the hilum and forming a distinct line almost all round the margin of the seed.

Endosperm and *embryo* very similar to those of V. Opulus, but the oval-oblong cotyledons are a little longer than the radicle.

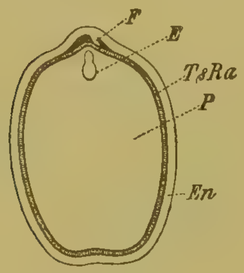

Fig. 423.—*Viburnum Lentago.* Longitudinal section of endocarp and seed, × 2: *F*, funicle; *E*, embryo; *T&Ra*, testa and raphe combined; *P*, endosperm; *En*, endocarp.

Viburnum Lantana, *L.*

Drupe oblong, dorso-ventrally compressed; endocarp pale- or straw-coloured, ridged and furrowed longitudinally in conformity with the seed; otherwise as in the last species.

Seed nearly orbicular, much compressed dorso-ventrally with a median longitudinal ridge along one face and a corresponding furrow along the other, pale brownish-orange; raphe lateral, passing from the hilum round one edge of the seed and half way up the other to the chalaza; otherwise as in the last species.

Endosperm and *embryo* as in previous species; cotyledons ovate; radicle about half their length.

Viburnum lantanoides, *Michx.* (fig. 424).

Drupe oval-oblong, slightly compressed dorso-ventrally, narrowed to the apex and tipped with the persistent base of the style; mesocarp pulpy, dark-coloured; endocarp crustaceous, oblong, narrowed

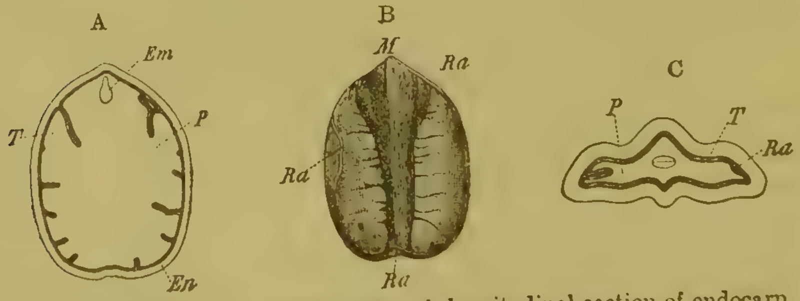

Fig. 424.—*Viburnum lantanoides.* A, longitudinal section of endocarp and seed, × 3: *Em*, embryo; *T*, testa; *P*, endosperm; *En*, endocarp. B, seed, × 3: *Ra*, *Ra*, *Ra*, raphe; *M*, micropyle. C, transverse section of endocarp and seed near its apex, × 6: *P*, endosperm *T*, testa; *Ra*, raphe.

at the upper and basal end into an obtuse tip, somewhat compressed dorso-ventrally, and raised on one face into four stout ridges with intermediate depressions, and having on the other a deep impression with a ridge in the centre, pale-coloured.

Seed conforming to the endocarp, dark brown, minutely pitted, glabrous ; testa thin, membranous, carried in folds into the endosperm ; raphe a reddish line passing from the hilum down the side of the seed, and winding round the end and up the opposite side for two-thirds of its length ; chalaza within one-third of the base of the seed.

Endosperm as before, but ruminate.

Embryo as before ; cotyledons oblong-ovate.

Viburnum montanum, ? *Auct.* (fig. 425).

Drupe obovoid ; endocarp crustaceous and variously involuted owing to indentations or cavities of the seed, as well as its infolded margins.

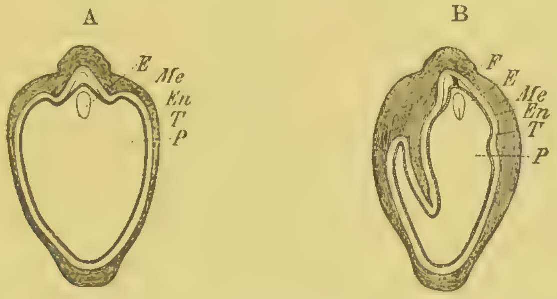

FIG. 425.—*Viburnum montanum*, × 4. A, longitudinal section of fruit : *E*, embryo ; *Me*, mesocarp ; *En*, endocarp ; *T*, testa ; *P*, endosperm. B, longitudinal section through the narrow plane of the seed : *F*, funicle ; *E*, embryo ; *Me*, mesocarp ; *En*, endocarp ; *T*, testa ; *P*, endosperm.

Seed somewhat obovoid, suddenly narrowed at its upper end, deeply infolded at the sides on the ventral aspect, and shallowly on the dorsal aspect near, or at the top, leaving a median ridge which contains the embryo ; raphe lateral, passing round the seed just within the infolded margins and consequently appearing ventral ; chalaza a short distance from the hilum ; testa thin, membranous, pale yellowish.

Endosperm fleshy, pale yellowish or transparent, occupying almost the whole of the seed.

Embryo minute, ovoid-oblong, embedded in a thickened and pointed part of the endosperm close to the micropyle and hilum ; radicle very blunt, subturbinate, about equal to the cotyledons in length ; cotyledons ovate, obtuse, entire, plano-convex, applied to each other face to face.

Viburnum punctatum, *Hamilt.* (fig. 426).

Hypocotyl scurfy with deciduous scales, pale green, 3·6 cm. long.

Cotyledons foliaceous, oblong-ovate, obtuse, seven-nerved, with scurfy scales; lamina 1·7 cm. long, 9 mm. wide; petiole grooved over 2·5 mm. long.

Stem woody, erect, quadrangular, densely scurfy with brown scales; 1st internode 9 mm. long; 2nd and 3rd each 3·5 mm; 4th 6 mm.; 5th 7·5 mm.

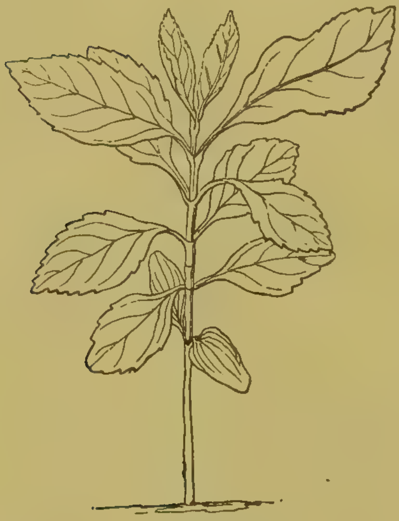
FIG. 426.—*Viburnum punctatum.* Half nat. size.

Leaves opposite, decussate, exstipulate, shining above and thinly scurfy, densely so beneath, alternately penninerved; petioles grooved above, subcarinate beneath with the carina continuous with the angles of the stem.

First pair ovate-elliptic, obtuse, mucronately serrate-dentate on the upper half.

Third, fourth, and fifth pairs elliptic, obtuse, mucronately serrate-dentate on the upper two-thirds.

Ultimate leaves oblong-elliptic, obtuse or acuminate, nearly smooth on the upper surface, and closely dotted with round scales beneath, alternately incurvinerved.

Triosteum pinnatifidum, *Maxim.*

Hypocotyl 4–8 mm. above the soil.

Cotyledons broadly oblong, obtuse, entire with a prominent terminal gland or slightly emarginate, petiolate, conspicuously reticulated, with three nerves running from near the base to the apex of the lamina, light green above, paler beneath, glabrous; lamina 1–1·3 cm. long, 7–9 mm. wide; petiole erect, grooved above, connate at the base, forming a cylinder or tube round the stem.

Stem erect, terete, coarsely hairy, the shorter hairs bearing orange-coloured glands; 1st internode variable, 1–4·2 cm. long.

Leaves exstipulate, incurvinerved and prominently reticulated, hairy on both surfaces; petiole winged, owing to the decurrent lamina, slightly connate at the base, channelled above.

First and second pairs lanceolate, obtuse, or subacute, mucronate.

On one year old seedlings the leaves are broader and lanceolate to elliptic; some of them are rhomboid and deeply trilobed or cut on one side only with rounded sinuses, and the lateral lobes ovate, while the terminal ones are broadly triangular; base much decurrent on the shortened petiole. These cut leaves also appear irregularly amongst others, both above and below, which are entire.

Symphoricarpus racemosus, *Michx.*

Ovary of four carpels, four-celled—two cells each with four to five aborted ovules—the other two each with a solitary pendulous anatropous perfect ovule; micropyle superior, close to the hilum.

Fruit a berry, globose, white, surmounted by four to five small teeth, the remains of the calyx, four-celled, with two perfect seeds.

Seed oval-oblong, slightly compressed dorso-ventrally, smooth, white; testa bony; tegmen thin, membranous, pale brown; hilum near the base (otherwise the upper end of the seed) forming a shallow cavity; raphe inconspicuous.

Endosperm and *embryo* as in Viburnum; cotyledons oblong-ovate; radicle cylindrical, equal to the cotyledons in length.

Lonicera Periclymenum, *L., var.* serotinum.

Ovary crowned with the persistent calyx, of two to three carpels, two- to three-celled, many-ovuled; ovules pendulous from the apex of the cell, anatropous; micropyle superior.

Fruit a berry, globose, glabrous, red when mature, two- to three-celled or one-celled by the destruction of the septa, few-seeded; exocarp and endocarp thin, membranous; mesocarp pulpy.

Seed oblong, plano-convex, or somewhat biconvex, obtuse at each end, generally broadest at the apex, often appearing obliquely notched at the base owing to the hilum being slightly lateral; testa pale brownish-yellow, thick, crustaceous; tegmen thin, membranous; micropyle basal; raphe and chalaza inconspicuous.

Endosperm copious, fleshy, almost colourless, split down the centre a considerable way, but occupying the greater part of the seed.

Embryo small, straight, embedded in the endosperm close to the base of the seed; cotyledons oblong or ovate; radicle shortly oblong, suddenly narrowed to an obtuse point, nearly or quite as long as the cotyledons.

Lonicera Munroi, ? *Hort.* (fig. 427).

Primary root very long, wiry, slender, with numerous slender lateral rootlets.

Hypocotyl erect, terete, glabrous, slender, purplish, 1·2–2·1 cm. long.

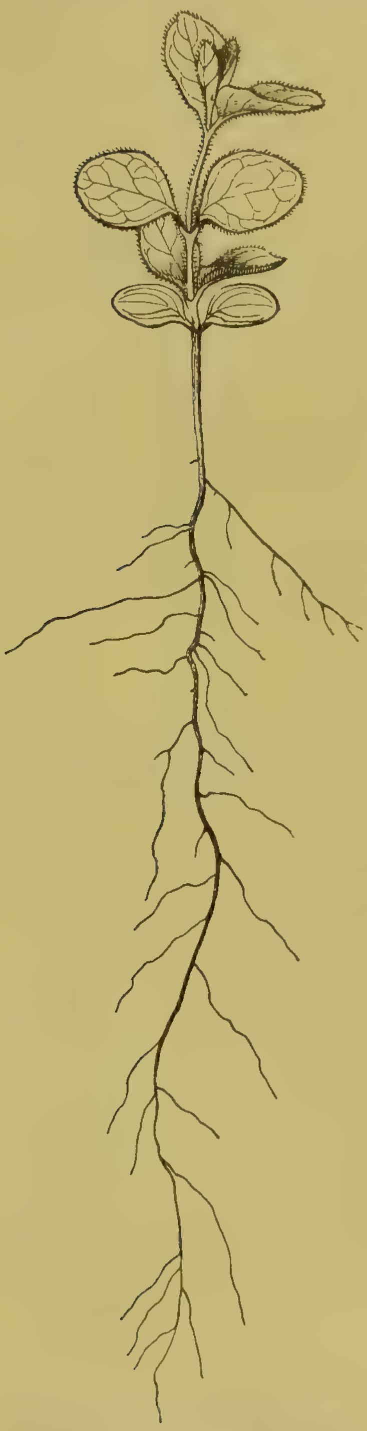

FIG. 427.—*Lonicera Munroi.* Nat. size.

Cotyledons oblong-oval, obtuse, entire or obsoletely emarginate, alternately nerved with one or two of the lower pairs stronger than the rest, if one pair they become incurved and unite with the midrib near the apex, while if two pairs are strongly developed they unite about the middle of the cotyledon and then proceed to the apex, shortly petiolate, glabrous, subglaucous-green, often stained beneath with purple; lamina 6–8 mm. long, 4–5 mm. wide; petiole channelled above, convex on the back, connate at the base around the plumule, purplish, 1–1·25 mm. long, ciliate at the margin.

Stem erect, terete, thinly hairy or pubescent, green or purplish, ultimately shrubby; 1st internode 1·25–2 mm. long; 2nd 1·75–6 mm.; 3rd 6–10 mm.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, young ones densely ciliate, and hairy on both surfaces, with the hairs curved or bent towards the apex, alternately and incurvedly penninerved, the nerves uniting and forming a series of large reticulations towards the margin, glaucous-green at least in the young state; petioles short, grooved above, subcarinate or merely convex beneath, slightly connate at the base, more or less hairy.

First and second pairs small, oval, obtuse, suddenly tapering to the base.

Third and forth pairs oval, obtuse, often cuspidate, suddenly tapering to the base, somewhat larger than those below them.

Lonicera media, *Murr.*

Hypocotyl 8–12 mm. long, stained with red.

Cotyledons subrotund or ovate-oblong, obtuse, emarginate, petiolate, glabrous, subglaucous-green, distinctly trinerved, the nerves with numerous branched veinlets; when emerging from the seed some appear convolute, others not.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 2–3 mm. long.

First leaves entire, oblong-lanceolate, obtuse, glabrous, green, distinctly pinnatinerved, exstipulate; petioles short, very shallowly furrowed on the upper side.

RUBIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 7.

Fruit and Seed.—The ovary is inferior, crowned by a disc, and from one- to ten-celled. The ovules are numerous, twin, or solitary in each cell, and inserted on, or immersed in the placentas, or concave and surrounding them as in Galium, erect, ascending, horizontal, or pendulous, anatropous, semi-anatropous or amphitropous. The fruit is baccate, drupaceous, capsular or consists of dehiscent or indehiscent cocci, and varies with from two to ten, very rarely one cell. The seed varies greatly in size, and is immersed in the receptacle, or in pulp, or is quite free with a membranous, leathery, crustaceous or very rarely woody testa; it is however sometimes winged or appendiculate. Endosperm is usually copious, fleshy or horny, very rarely reduced to a thin layer or entirely wanting; it is either solid or ruminated. The embryo varies greatly in size, and is curved, straight or clavate. The cotyledons are flat, or semiterete, ovate or cordate, foliaceous, with a terete or clavate, superior or inferior radicle.

There are several distinct types of seeds in the Order. Exalbuminous seeds occur in species of Henriquezia, Platycarpum, and several of the tribe Guettardeæ. Ruminated seeds are met with in Coptosperma, Galiniera, Rutidea, Polysphæria, and in species of Psychotrieæ.

The seeds of Gardenia Thunbergia vary greatly in outline, being oval, oblong, orbicular or more or less angled, but always much compressed and surrounded or embedded in the pulp of the baccate, one-celled fruit. They owe their shape to mutual compression while still young. The embryo is about half the length of the endosperm, but much narrower, with roundly triangular cotyledons and a terete radicle. Genipa clusiæfolia (fig. 430) also belongs to this type. The seeds of Alberta magna (fig. 433) are oblong, bluntly trigonous and conform to the cells of the ovary, of which there are four, two barren and two fertile, each containing a single ovule. The embryo nearly equals the endosperm in length, and is situated near the dorsal aspect of the seed. The cotyledons are shortly and bluntly ovate, while the terete radicle is many times longer. The fruit is dry and surmounted by five very unequal, foliaceous, coloured sepals, of which generally two are larger than the rest, trinerved, reticulate, and rose-coloured in the dry state. They seem to assist in the dispersion of the fruit.

In two widely distinct groups of plants represented by Ixora and Galium, the seeds are deeply concave or umbilicate on the ventral aspect. The globular drupaceous fruit of Ixora congesta (fig. 434) is two-celled with a semiorbicular seed in each cell conforming in shape to the cavity. The embryo is curved in conformity with the shape of the comparatively thin seed; but in other respects it closely resembles that of Gardenia Thunbergia. The half-fruits of Galium Aparine (fig. 439) and G. saccharatum (fig. 441) are subglobular and deeply concave. The embryo is embedded in the copious horny endosperm, close to the ventral aspect. The pericarp of G. Aparine is dry, membranous and thin, while that of G. saccharatum consists of a dense layer of dry corky tubercles. The embryo of the latter is considerably narrower than that of the former; and this circumstance seems to have reference to the mode of exit of the respective embryos during germination.

A fourth type of seed is represented by that of Coffea arabica. The fruit is oblong, drupaceous, and two-celled with each cell one-seeded. The seed is large, oblong, plano-convex, corresponding in outline to one half of the fruit, and has a hard crustaceous testa. When mature, it shows a longitudinal slit or furrow in the middle or a little to one side of the ventral face. A transverse section of the seed shows that it grows much too wide for the cavity of the fruit, and becomes strongly infolded longitudinally with its lateral edges meeting on the ventral aspect. The embryo is like that of Gardenia Thunbergia and is located on the dorsal aspect at the lower end of the seed, with the radicle inferior as in the species of Galium and Ixora.

Seedlings.—There are many differences in matters of minor detail in seedlings of this Order; but the prevailing type of cotyledon is ovate and three- to five-nerved, while broadly ovate-triangular and elliptic forms may be considered as modifications. Those observed may be conveniently classified into four groups according as the species are herbaceous with ovate cotyledons; shrubby with ovate and generally larger cotyledons; thirdly, have more or less elliptic cotyledons; and, fourthly, orbicular or transversely oblong cotyledons. The first type is well represented by Rubia cordifolia (fig. 438). The cotyledons are ovate, five-nerved, and petiolate. The first pair of leaves are ovate-cordate, three- to five-nerved, and the stipules are similar but smaller, with less conspicuous venation. Galium tenuissimum has similar, but very small cotyledons, and the first three pairs of leaves are obovate and similar to, but slightly larger than, their stipules. Crucianella ægyptiaca (fig. 443) differs from the last named in the cotyledons being larger and emarginate. The first pair of leaves are lanceolate, and the four succeeding pairs linear-subulate with similar stipules. The seedling of Galium Aparine is almost as vigorous as that of Rubia cordifolia, but the cotyledons differ in being broadly oblong-ovate, trinerved, and emarginate. The broad cotyledons emerge from the thin-walled fruit by the splitting of the latter after the endosperm has been absorbed; the emargination is sometimes quite evident as soon as they have escaped from the seed, but as a rule it is not noticeable till later; it is due to the more rapid growth of the sides as compared with the apex where the water-pores, or at least the principal ones, are situated. The increase in size that takes place after germination is shown at fig. 440, representing the exact nature of the venation in a bleached specimen. The lateral nerves, at first close to the margin all round, are ultimately distant from it. Galium saccharatum (fig. 442) differs remarkably from its congeners and others in this group, in having linear-oblong emarginate cotyledons. The venation (fig. 442, B), drawn from a bleached specimen, is strikingly different from that of G. Aparine, a fact apparently due to growth in the basal portion of the lamina subsequent to germination. The narrowness of the lamina is necessary to facilitate the escape of the embryo from the narrow opening of the fruit, which has a thick warted and cortical pericarp as above mentioned.

The shrubby type is represented by Randia Mussændæ (fig. 428) having large ovate cotyledons tapering to the base, with a penninerved, incurved venation resembling that of the leaves, the first pair of which are elliptic. Leptodermis lanceolata conforms pretty closely to this type, and an unnamed species of Psychotria (fig. 437) differs chiefly in the cotyledons being shorter, broader, and almost truncate at the base. The latter also furnishes a remarkable instance of the presence of stipules to the cotyledons. The first two pairs of leaves are elliptic, and, like the cotyledons, have incurved nerves. Coffea arabica (fig. 436) has roundly ovate strongly trinerved and reticulate cotyledons, larger than any others of the Order coming under my notice. The first four pairs of leaves are lanceolate-elliptic. Ixora parviflora has roundly triangular cotyledons with a cordate base and very prominent venation. As amongst the herbaceous types, so here we have a strong divergence from the usual form. The cotyledons of Plectronia ventosa are linear-oblong, obtuse, penninerved, sessile, and leathery like the leaves. The two first leaves are ovate. Another exceptional instance occurs in Rudgea Hostmani which has broadly reniform cotyledons, but in the specimen noted they were evidently malformed. The first pair of leaves are oblong ; the second broader.

A few constituting a third group have elliptic cotyledons. Taking Genipa clusiæfolia (fig. 432) as a type, it will be seen that the cotyledons possess no very marked characters separating this from the last group, and while still in the seed and in the course of germination they are strictly ovate. After leaving the testa they elongate or become cuneate at the base and are then broadly oval or elliptic and trinerved. They are remarkable although not unique in being stipulate like the species of Psychotria above mentioned. While the cotyledons are still in the germinating seed (fig. 431) the stipules form minute protuberances covered with unicellular hairs. After germination and while the cotyledons are still broadly ovate, the stipules enlarge, and although still very small they serve to protect the plumule lying as a little bud between them. A more marked type is represented by Morinda tinctoria, the cotyledons of which are broadly elliptic and penninerved with ascending nerves as happens more commonly in true leaves. The first pair of the latter in this case are linear-lanceolate and many times narrower than the cotyledons. Pavetta speciosa may also be placed here. The cotyledons are penninerved and stipulate; and the two first pairs of leaves are oblong, tapering at the base. A fourth type includes those species having orbicular or transversely oblong cotyledons. An herbaceous type is represented by Sherardia arvensis (fig. 444) having orbicular entire trinerved cotyledons. The leaves closely correspond to those of Galium; the first pair are obovate, with smaller but similarly foliaceous stipules. In the next two whorls the leaves and stipules more nearly approximate in size, and there are only two stipules. As the plant assumes the adult form, the leaves become lanceolate and each pair possesses two pairs of stipules similar to themselves, making a whorl of six. Pavetta madagascariensis (fig. 435) is a shrubby type with transversely oblong or suborbicular cotyledons and triangular interpetiolar stipules. The two first pairs of leaves are elliptic-oblong. The cotyledons of Gardenia globosa are similar and trinerved, and the first three pairs of leaves are oblong, obtuse, and more or less pubescent. In Gardenia Thunbergia (fig. 429) the cotyledons are obovate, emarginate and penninerved. The first five pairs of leaves are obovate, penninerved and tapered to the base. The ultimate ones are lanceolate-elliptic, attenuated at the base and opposite, or in whorls of three.

Randia Mussændæ, *DC.* (fig. 428).

Hypocotyl woody, erect, terete, pubescent, pale green, about 1·4 cm. above the soil.

Cotyledons large, foliaceous, ovate, rounded at the apex, tapering to the base, alternately penninerved, but most conspicuously on the lower half, glabrous, coriaceous but thin, deep green and shining above, paler beneath, 2·1 cm. long, 1·5 cm. wide.

Stem woody, erect, terete, pubescent, pale green; 1st internode 1·2 cm. long.

Leaves simple, entire, cauline, opposite, stipulate, shortly petiolate, bright green and shining above, thinly pubescent, ciliate, paler beneath and thinly pubescent on the nerves, alternately penninerved; stipules interpetiolar, united and forming one subulate, attenuate piece between each pair of leaves; petioles flattened above, convex beneath, thickened at the base, very short, pubescent.

First pair lanceolate, subacute, tapering most at the base.

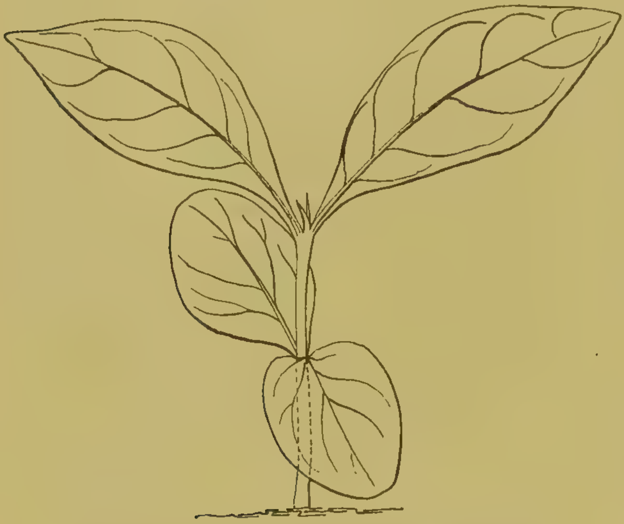

Fig. 428.- *Randia Mussændæ.* Nat. size.

Gardenia Thunbergia, *L. fil.*

Fruit baccate, globose or ellipsoid, ultimately more or less cortical externally when dry, and crustaceous internally or somewhat bony, one-celled, many-seeded, indehiscent; placentas ultimately forming a pulpy mass in which the seeds are embedded.

Seed oblong, oval, or orbicular, variously and obtusely angled, thin, much compressed and more or less flattened on both sides, or turgid or convex on one side and flattened on the other, immersed in pulp, and comparatively large, 6–7 mm. long, 4–5·5 mm. broad, and 1–2 mm. thick in a dried state; testa thin, membranous, pale brown or whitish; hilum and micropyle basal, contiguous.

Endosperm copious, horny, almost colourless, and subtransparent.

Embryo straight, colourless, about half the length of the seed, but several times narrower; cotyledons rotund-triangular, very obtuse and rounded at the apex, flat or nearly so, closely applied face to face and thin, lying in the broader plane of the seed and consequently horizontal to the base of the fruit; radicle terete, suddenly narrowed to an obtuse point towards the micropyle and close to the hilum, rather longer than the cotyledons.

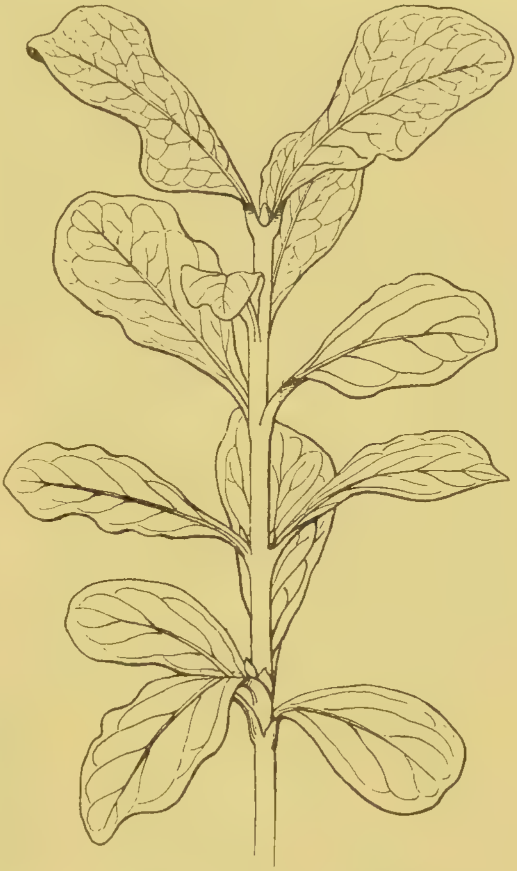

FIG. 429.—*Gardenia Thunbergia.* Nat. size.

Seedling (fig. 429).

Hypocotyl erect, terete, soon becoming woody, 1·4 cm. above the soil.

Cotyledons large, foliaceous, obovate, emarginate, tapering to a narrow subpetiolate base, and clasping the stem between them, about 2·5 cm. long, 1·2 cm. wide.

Stem woody, erect, terete, pubescent, afterwards becoming glabrous or nearly so, bright green and afterwards grey when the epidermis becomes torn longitudinally; 1st internode undeveloped; 2nd 2·5 cm. long; 3rd 1·3 cm.; 4th 9 mm.; 5th 1·1 cm.

These lengths vary with the specimen. Another stem measured: 1st internode undeveloped; 2nd 8 mm. long; 3rd 1·6 cm.; 4th 1·65 cm.; 5th 1·25 cm.; 6th 1·6 cm.; 7th 2·2 cm.; 8th 2 cm.; 9th 2·5 cm.

Leaves opposite or in whorls of three, frequently undulate, but quite entire, penninerved with alternate, ascending nerves, deep green above and glabrous, but scabrous at the margins and on the midrib, shining, paler beneath and shining, scabrous on the nerves, with a white midrib prominent on both surfaces; petioles very short and thickened at their insertion; tufts of hairs in the axils of the leaves; stipules interpetiolar, closely clasping the stem, and forming a sheath which splits somewhat irregularly on one or two sides. The latter are not very conspicuous, and I see that the artist has unfortunately overlooked them.

Lower leaves oblanceolate, obtuse, tapering much to the base; those about the eighth or ninth pair or whorl lanceolate-elliptic, obtuse, undulate at the margin especially in the upper part of the leaf, tapering very much towards the base with straight, even margins.

Ultimate leaves generally in whorls of three, and most frequently one or two are much smaller than the third. Large leaves lanceolate-elliptic, much narrowed to both ends, or broadly elliptic, subrhomboid and suddenly narrowed to both ends, obtuse or acute, deep green and shining, margins much undulated.

Genipa clusiæfolia, *Griseb.* (figs. 430, 431).

Fruit baccate, fleshy, ovoid, with a thick or corky pericarp, and the numerous seeds embedded in pulp.

Seed very much flattened and rather thin, suborbicular or variously angled, albuminous; testa pale brown, thin, subtransparent as well as the endosperm, and showing the outline of the embryo very distinctly when the seed is held up to the light; raphe forming a black line running round the edge of the seed.

Embryo comparatively large, and about a third the length of the seed, colourless; cotyledons roundly cordate, closely adpressed to one another, lying in the broader plane of the seed, trinerved with a prominent midrib, situated towards the micropylar end of the seed, surrounded by endosperm, with their basal edges towards the hilum; radicle about equal to the cotyledons in length, terete, obtuse, slightly stouter where the cotyledons are inserted.

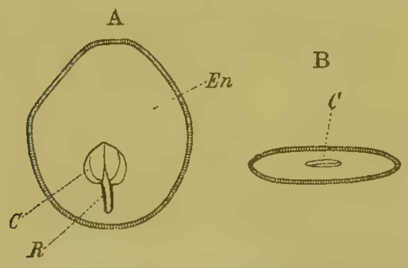

Fig. 430.—*Genipa clusiæfolia*, × 2½. A, longitudinal section of seed: *En*, endosperm; *C*, cotyledon; *R*, radicle. B, transverse section of seed: *C*, cotyledons.

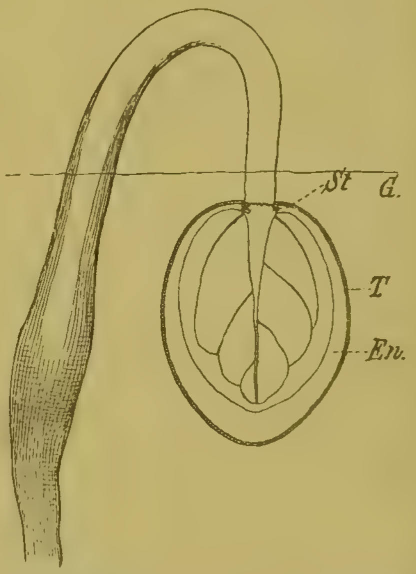

Fig. 431.—*Genipa clusiæfolia*. Germinating seedling with side of seed and one cotyledon removed, × 4: *En*, endosperm; *T*, testa; *St*, little protuberance covered with unicellular, blunt hairs; *G*, ground line.

Seedling (fig. 432).

Hypocotyl erect, terete, minutely scabrous, pale brownish, 1·8–2·4 cm. above the soil.

Cotyledons ovate or obovate-elliptic, obtuse, entire, shortly petiolate, tapering into the petiole, trinerved from the base, with the lateral nerves incurved and uniting with the midrib at its apex, with alternate, incurved nerves between, coriaceous, slightly revolute at the margins, glabrous, deep green above, paler beneath, and shining on both surfaces; lamina 1·5–1·65 cm. long, 1–1·2 cm. wide; petiole flattened above, 1–2 mm. long; stipules interpetiolar, united into one ovate, acute piece, colourless and subscarious.

Stem erect, terete, ultimately woody, densely pubescent; 1st internode 1–2 mm. long; 2nd shorter.

Leaves entire, shortly petiolate or subsessile, decussate, somewhat leathery, bright green and shining above, glabrous,

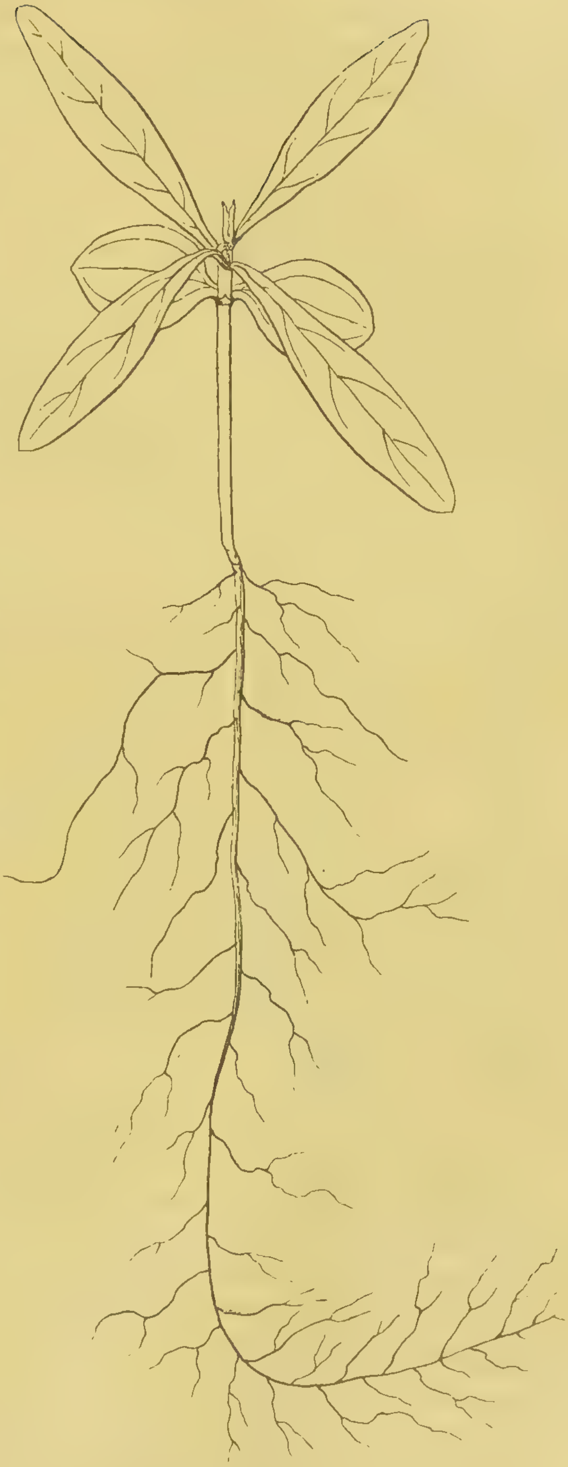

FIG. 432.—*Genipa clusiæfolia*
Nat. size.

except a band along the margin, appearing reticulate by transmitted light; petioles very short or almost none; stipules interpetiolar, subulate-ovate, acute, the hairs united in one piece, pale brown or grey.

First and second pairs oblong-lanceolate, mucronate, subacute, entire, revolute at the margin.

Alberta magna, *E. Mey.* (fig. 433).

Fruit two-celled, each cell one-seeded, or sometimes empty, dry, woody, indehiscent, oblong, ten-ribbed, surmounted by the persistent calyx, two to four, generally two, segments of which become greatly enlarged, leaf-like, and coloured (rose in the dry state); enlarged calyx-lobes unequal, trinerved and much reticulated, with the three primary nerves running down the fruit, forming as many ribs to the latter, while the three small calyx-lobes have a prominent midrib, but nearly obsolete lateral ones.

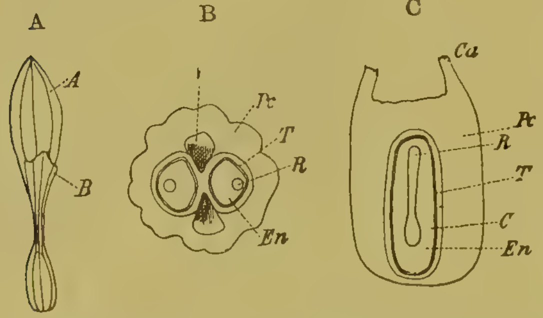

FIG. 433.—*Alberta magna.* A, fruit, nat. size: *A* and *B*, two of the calyx-lobes developed into wings; part of *B* is broken off. B, transverse section of fruit, × 4: *Pc*, pericarp; *T*, testa; *R*, radicle of embryo; *En*, endosperm; *V*, cavity appearing like an aborted cell in dry fruit. C, longitudinal section of fruit, × 4: *Ca*, calyx; *Pc*, pericarp; *R*, radicle; *T*, testa; *C*, cotyledon; *En*, endosperm.

Seed oblong, rather slender, conforming to the cavity of the ovary, albuminous; endosperm fleshy, dirty-white, occupying the greater part of the seed; testa thin, adhering to a fleshy layer of the endosperm.

Embryo nearly as long as the endosperm, but thin and occupying only a very small portion of it, straight, colourless; radicle terete, blunt, slightly thickened at the apex, pointing to the upper end of the seed with its tip just within the endosperm, several times longer than the cotyledons, which are shortly and very bluntly ovate, flat, closely adpressed to one another and embedded in the endosperm with their faces to the axis of the fruit, and therefore in the slightly broader plane of the seed.

Plectronia ventosa, *L.*

Hypocotyl erect, terete, glabrous, 2·5–3 cm. long, green.

Cotyledons linear-oblong, obtuse, entire, coriaceous, sessile, glabrous, shining green, penninerved like the leaves.

Stem erect, terete, hairy, herbaceous; 1st internode 1·5–3 mm. long.

First leaves ovate-lanceolate, obtuse, acuminate, shortly petiolate, exstipulate, with a few scattered hairs, shiny green, distinctly and alternately penninerved.

Ixora parviflora, *Vahl.*

Hypocotyl very firm, 2·5 cm. long, 1 mm. thick, terete, glabrous, purplish-red.

Cotyledons unequal, with connate, rather short petioles, 1·2–1·5 cm. long, and 1·5–1·8 cm. wide; lamina horizontal, obtusely triangular or oblate, cordate at base, very obtuse at apex, entire, palmatinerved, with copious anastomosing veins, glabrous, coriaceous, dark shining green above, paler beneath.

Stem very short, pubescent at first, marked with red striæ.

Leaves shortly petiolate or subsessile, alternately incurvinerved, coriaceous, evergreen, deep green above, paler beneath; stipules interpetiolar, connate, with a broad base, and an acute, more or less acuminate point.

First pair subsessile, 1–1·5 cm. long, and about 6 mm. wide, spathulate-obovate, penninerved.

Second pair remaining very minute for a long time after the unfolding of the first.

Ixora congesta, *Roxb.* (fig. 434).

Ovary two-celled, two-ovuled; ovules peltate, amphitropous; micropyle inferior.

Fruit baccate, subdidymous when both carpels are fertilised and come to maturity, but globose if only one is fertilised and perfect, glabrous, one- to two-celled and one- to two-seeded; endocarp hard and tough, convex or rounded dorsally, concave with an orbicular ventral orifice, pale brown, marked with darker spots; mesocarp fleshy; epicarp dark purple or black.

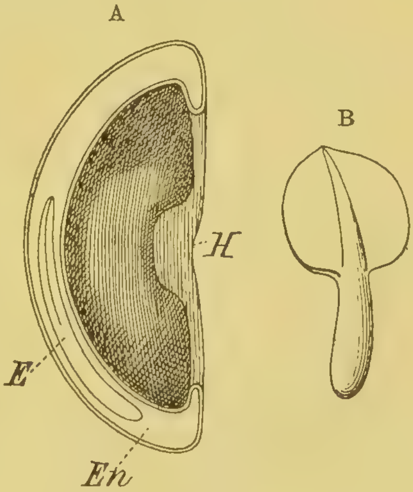

FIG. 434.—*Ixora congesta.* A, longitudinal section of seed, × 8: *E*, embryo; *En*, endosperm; *H*, hilum. B, embryo, × 8.

Seed conforming to the endocarp, rounded on the back, deeply concave on the ventral aspect at its insertion on the placenta, and peltate, glabrous; testa thin, membranous; hilum forming a large peltate disc, covering over the concavity of the seed; micropyle inferior.

Endosperm copious, cartilaginous and very hard when dry.

Embryo central in the endosperm, curved longitudinally and also transversely in conformity with the shape of the seed; cotyledons triangular-ovate, obtuse, entire, thin; radicle cylindrical, obtuse, pointing to the micropyle at the lower side of the hilum, longer than the cotyledons.

Pavetta madagascariensis, ? *Auct.* (fig. 435).

Hypocotyl woody, erect, terete, glabrous, scabrous, pale green, 1–1·5 cm. above the soil.

Cotyledons semiorbicular or oblate, entire, glabrous, shining, coriaceous, horizontal, petiolate, penninerved; lamina 1·1 cm. long, 1·5 cm. wide; petiole 2 mm. long, flattened above, convex beneath; stipules short, triangular, acute, interpetiolar.

Stem woody, erect, terete, pubescent, scabrous, green; 1st internode 6 mm. long; 2nd 3 mm.

Leaves entire, glabrous, shining, deep green above, paler beneath, alternately penninerved, coriaceous; stipules interpetiolar, ovate, acute, connate in one piece.

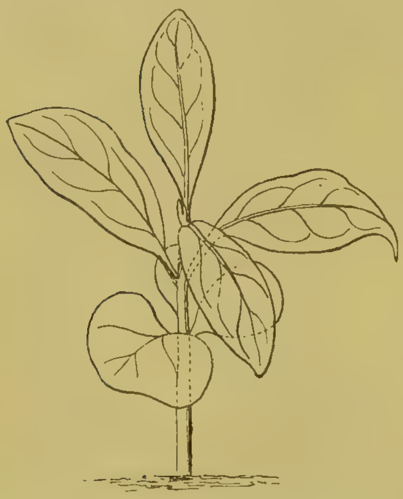

Fig. 435.—*Pavetta madagascariensis.* Nat. size.

First and second pairs elliptic-oblong, obtuse.

In **Pavetta speciosa** the cotyledons are rotund-cuneate; lamina 1 cm. long, 1·1 cm. wide.

Coffea arabica, *L.* (fig. 436).

Primary root a long taproot, woody, with a great many branched, greyish, fibrous lateral rootlets.

Hypocotyl woody after a time, about 6 cm. long, 2–3 mm. thick, round, with a greyish-brown coriaceous rind bursting open in broad longitudinal fissures, and showing the green layer below.

Cotyledons sessile, frequently three in number, about 3·5 cm. long, 4·5 cm. wide, oblate, apex obtuse, margin sinuate, with five sunk nerves and distinctly reticulate, coriaceous, glabrous and shining on both sides, dark green above, paler beneath.

Stem.—1st and 2nd internodes 2 cm. long, resembling the hypocotyl.

Leaves entire, lanceolate-elliptic, alternately incurvinerved and reticulate, glabrous, evergreen, subcoriaceous, deep green above, paler beneath; petioles very short, flattened above; stipules interpetiolar, connate, very persistent, with a broad base and one or both tips free and more or less acuminate, closely applied to the stem.

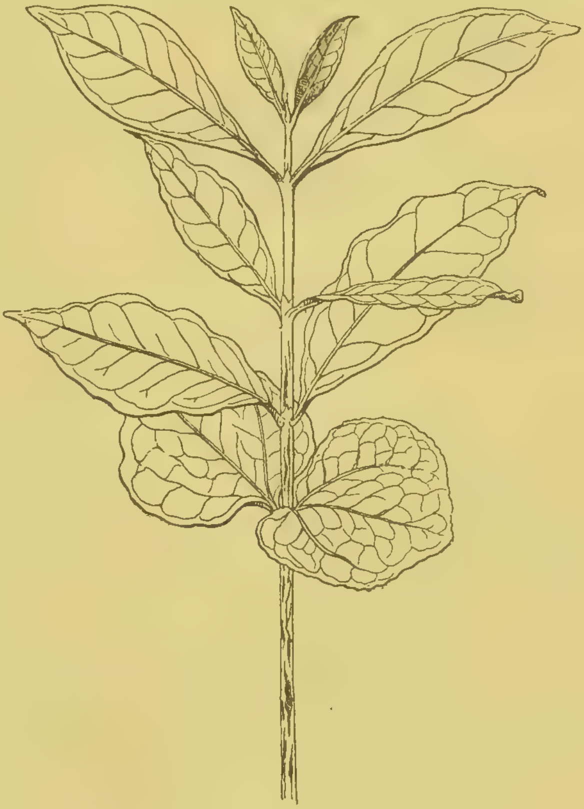

FIG. 436.—*Coffea arabica.* Half nat. size.

Morinda tinctoria, *Roxb.*

Hypocotyl erect, flattened, glabrous, short, about 5 mm. long, light green or almost colourless.

Cotyledons obtusely ovate, glabrous, shortly petiolate, about 1·5 cm. long by 1 cm. wide, dull green, entire; midrib with numerous ascending veinlets, as in the leaves.

Stem herbaceous, erect, quadrangular, ultimately woody, glabrous, light green; 1st internode 1–2 mm. long.

Leaves entire, linear, acute, shortly petiolate or subsessile, with connate interpetiolar stipules, glabrous, dark green above, lighter below; midrib prominent with ascending veinlets.

Psychotria sp. (fig. 437).

Primary root long, tapering, much branched.

Hypocotyl erect, terete, 2·5–3·5 cm. long, glabrous.

Cotyledons broadly ovate, obtuse, petiolate, alternately incurvinerved, somewhat coriaceous, glabrous, shining, stipulate; lamina 9–12 mm. long, 9–11 mm. wide at the base; petiole flattened above, 3 mm. long; stipules interpetiolar and united so as to form one ovate, acuminate piece between each petiole, soon becoming dry, brown, and scarious.

Stem erect, and in the seedling stage at least having ridges running downwards from the base of the interpetiolar stipules.

Leaves opposite, decussate, alternately incurvinerved, subcoriaceous, shining, deep green above, paler beneath, shortly petiolate; stipules interpetiolar, subscarious.

First and second pairs of leaves ovate, obtuse, entire.

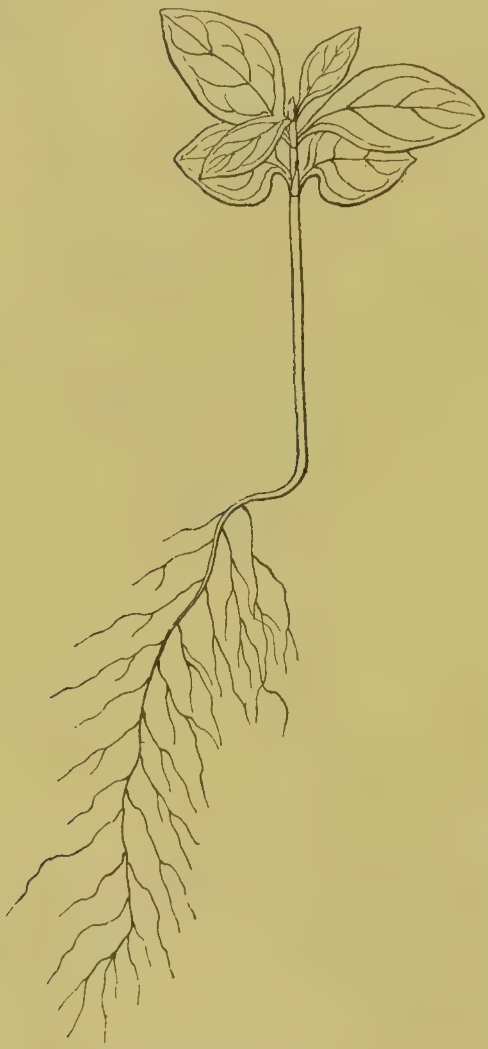

FIG 437.—*Psychotria sp.* Nat. size.

Rubia cordifolia, *L.* (fig. 438).

Primary root tapering downwards, flexuose, with numerous lateral rootlets, orange-red.

Hypocotyl erect, terete, glabrous, minutely scaberulous, yellowish, 3–3·5 cm. long.

Cotyledons ovate, obtuse, entire, trinerved from the base or sometimes five-nerved, with the two stronger laterals incurved and uniting with the midrib near the apex of the lamina, reticulate, glabrous, petiolate, light green or stained with dull red; lamina 1·4–1·65 cm. long, 9–10·5 mm. wide; petiole semiterete, channelled above, minutely pubescent at the edges, or scaberulous, glandular at the base and slightly connate, 4–5 mm. long.

Stem erect in the seedling stage, ultimately climbing, herbaceous, rather acutely quadrangular, with transparent cartilaginous edges, glabrous, shining, green; 1st internode 2–2·5 cm. long.

Leaves opposite (described in 'Genera Plantarum' as in whorls of four, rarely six), three- to five-nerved like the cotyledons, obscurely reticulate, thinly pubescent above, with short hairs directed towards the apex, less so beneath, and glabrescent when old stipules similar to the leaves but smaller, at least in the early stage; petioles short, semiterete, slightly tapered upwards, channelled on the upper side, slightly scaberulous with short hairs, and an interpetiolar transverse line of hairs or small bristles.

First pair of leaves ovate, obtuse, cordate at the base, three- or less distinctly five-nerved; stipules similar but much narrower and less distinctly nerved, petiolate, cordate at the base.

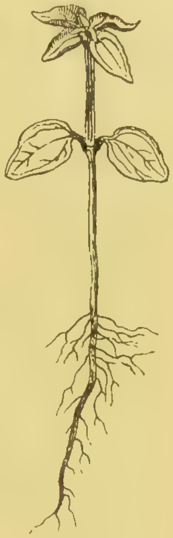
FIG. 438.
Rubia cordifolia.
Half nat. size.

Galium Aparine, *L.* (figs. 439, 440).

Fruit didymous, densely covered with hooked prickles, indehiscent, falling away in two separate pieces.

Seed subglobose, ventrally attached and peltate, with a deep round hollow on the ventral aspect caused by the indentation of the testa, dark brown or black, finely reticulate; raphe ventral in the interior of the cavity; radicle inferior, close to the edge of the cavity.

Endosperm copious, pale subtransparent white, horny.

Embryo curved and reaching from the micropyle near the outer edge of the ventral cavity for about three-quarters the distance to the other side, colourless, embedded in the endosperm; cotyledons oblong-ovate, obtuse, emarginate, covered on the upper surface with clear colourless or crystalline points or prickles directed towards the apex, trinerved at the base with stronger lateral nerves upwards, all of which are incurved, the basal ones uniting with those above them, which then converge and unite in the apical sinus.

During germination the endosperm is absorbed, and the cotyledons increasing at the same time fill the internal cavity of the seed; the radicle pushes its way into the soil where it throws out lateral rootlets; the hypocotyl is the first to appear above ground and pulls the now largely developed cotyledons out of the soil, without the testa if the seed is buried sufficiently deep, otherwise the testa is carried up on their tips. The cotyledons were folded over the large indented process of the pericarp, and are thus necessarily concave, the emarginate apex abuts on the upper side of the same indentation, and they are undulated or crisped in the middle owing to the resistance at their apex and base. The testa and pericarp at the latter place finally give way and the cotyledons are drawn out.

Galium saccharatum, *All.* (fig. 441).

Fruit deeply bilobed, almost separated into two pieces, two-

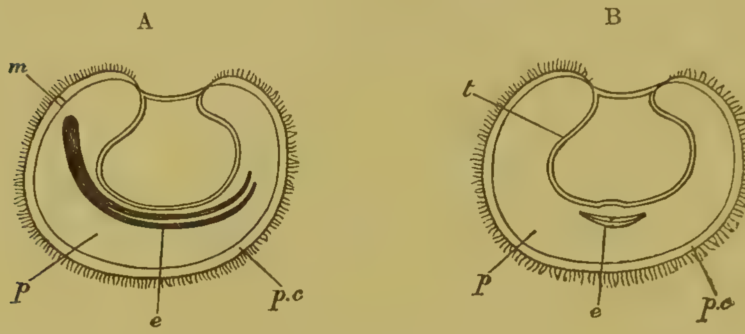

Fig. 439.—*Galium Aparine.* A, longitudinal section of seed, × 8: *m*, micropyle; *t*, testa; *pc*, pericarp; *e*, embryo; *p*, endosperm. B, transverse section, × 8.

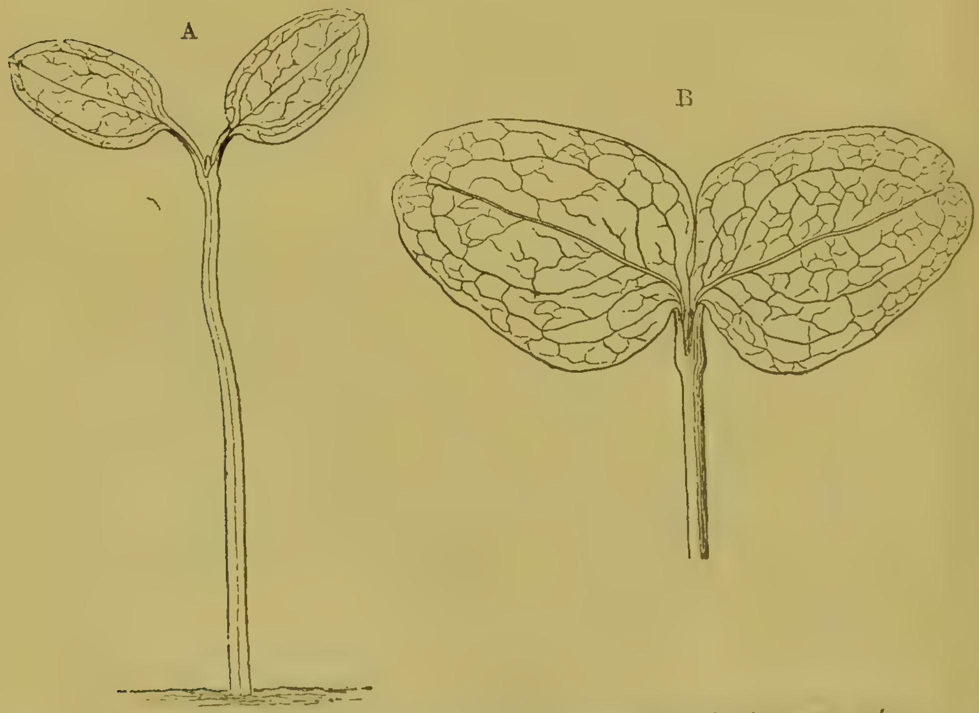

Fig. 440.—*Galium Aparine*, × 2. A, young seedling. B, the same, a few days older. (Bleached to show venation.)

celled, two-seeded, indehiscent; pericarp densely covered with corky tubercles.

Seed adhering to the pericarp, convex on the back, deeply hollowed on the ventral aspect; testa thin, membranous; hilum on the middle of the concave ventral aspect.

Endosperm abundant, horny.

Embryo curved, following the convexity of the hollow with the greater part of the endosperm towards the periphery, and only a thin layer between it and the inner or ventral aspect of the seed, colourless, and three-quarters the length of the seed; cotyledons linear, obtuse; radicle inferior, curved round nearly but not quite to the edge of the concavity.

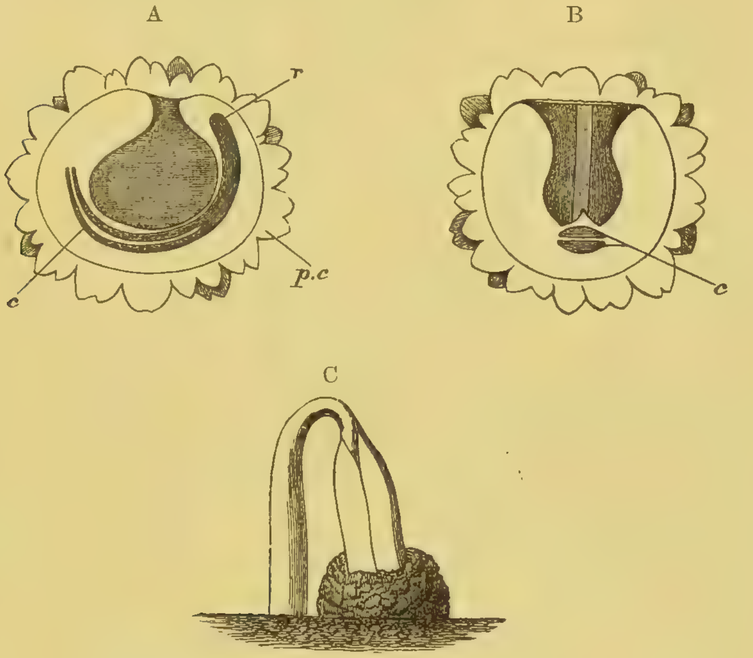

FIG. 441.—*Galium saccharatum.* A, longitudinal section of seed, × 8: *c*, cotyledons; *r*, radicle. B, transverse section of seed, × 8: *c*, cotyledons. C, germinating seedling, × 4.

Seedling (fig. 442).

Primary root long, tapering, fibrous, annual, yellow with reddish lateral rootlets.

Hypocotyl erect, terete, scabrid with short deflexed prickles, pale green, about 1·85 cm. long.

Cotyledons linear, obtuse, minutely emarginate, margin with minute deflexed prickles, surface glabrous, tapered to the base, 2·1 cm. long, 4 mm. wide. Three to five buds are ultimately developed in the axils of the cotyledons.

Stem herbaceous, annual, erect, ultimately climbing by means of the minute prickles, quadrangular, with minute deflexed prickles on the angles, swollen at the nodes; 1st internode 1·6 cm. long; 2nd 5 mm.

Leaves opposite or verticillate, narrowed to a short petiole, ciliate at the margin with minute prickles directed towards the apex,

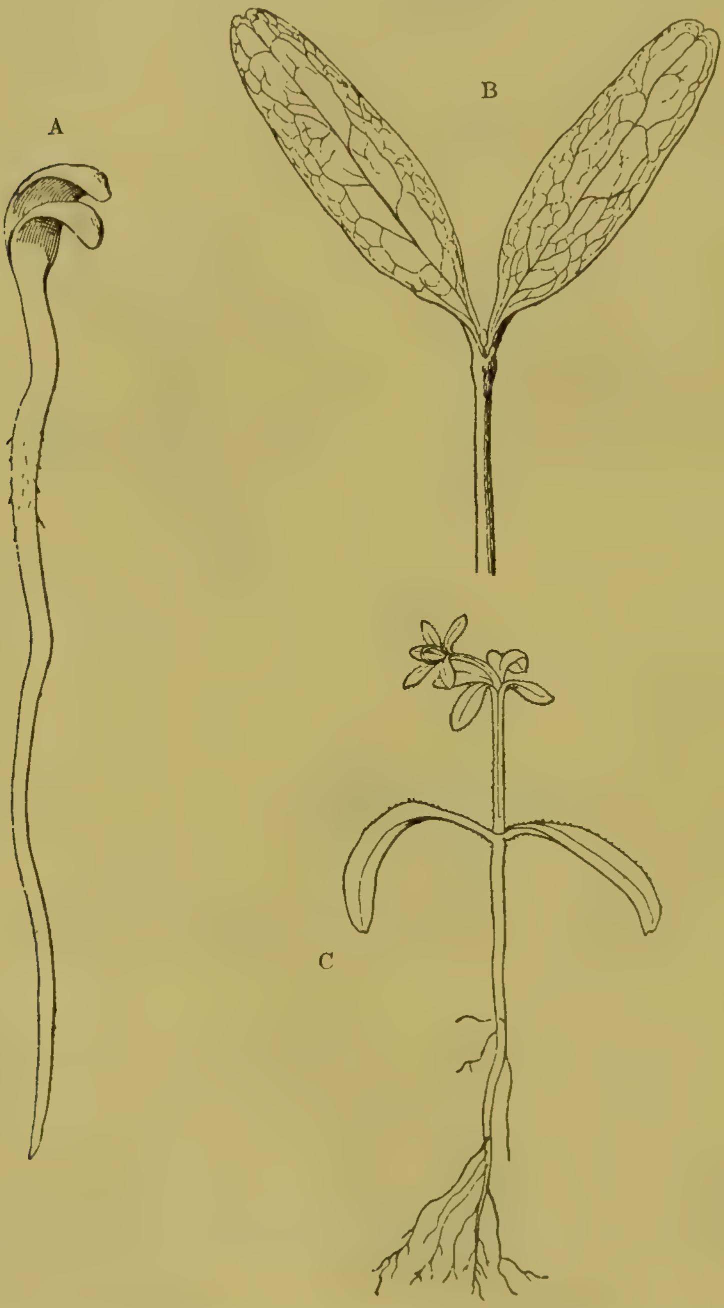

Fig. 442.—*Galium saccharatum.* Seedlings in three stages: A, very young, × 4; B, cotyledons from a slightly older seedling, × 2 (bleached to show venation); C, older seedling, nat. size.

light rather opaque green; petioles very short, channelled above, subcarinate beneath; stipules interpetiolar, similar to the leaves in every respect, but smaller in the seedling stage.

First pair oblanceolate, cuspidate, channelled above, with the midrib prominent beneath; stipules interpetiolar and single between the leaves.

Second pair decussating with the first and similar; stipules similar to the leaves, two on one side of the stem and one on the other, making in all with the leaves five.

Third pair ditto, but sometimes with all the four stipules developed.

Fourth pair with the four stipules present.

Galium tenuissimum, *M. Bieb.*

Primary root similar to that of the last species.

Hypocotyl erect, tapering insensibly into the root, green above soil, glabrous.

Cotyledons ovate, obtuse, entire, with one median nerve shortly petiolate, glabrous; lamina 2·75 mm. long, 2 mm. wide; petiole flattened above, about 1 mm. long.

Stem annual, erect, quadrangular, glabrous or with a few minute scattered prickles on the angles; 1st internode 5 mm. long; 2nd 5·5 mm.; 3rd 7 mm.

Leaves opposite and verticillate, with large interpetiolar foliaceous stipules, shortly petiolate, glabrous or with a few minute scattered prickles on the upper surface and margin, acute or apiculate, one-nerved only in seedling stage; stipules exactly similar to the leaves but smaller (at least in the seedling).

First whorl of two leaves and two stipules, obovate or subelliptic, shortly petiolate.

Second whorl similar, the larger members (leaves) decussating with those below them.

Third whorl of two leaves and four stipules.

Crucianella ægyptiaca, *L.* (fig. 443).

Primary root long, wiry, tapering, flexuose, brownish-red, with short lateral fibres, annual.

Hypocotyl erect, terete, very short, tapering indistinguishably into the root, scaberulous.

Cotyledons ovate, obtuse, emarginate, shortly petiolate, with a distinct midrib, and one to two alternate, ascending, incurved nerves on each side, but difficultly discernible in the fresh state, glabrous, dull deep green above, paler beneath; lamina 4·5-5·5 mm. long, 2·75–3·25 mm. wide; petiole broad, dilated and subconnate at the base, 1–1·25 mm. long.

Stem herbaceous, annual, erect, quadrangular, angles prominent, acute, scaberulous with decurved hard points or prickles, glaucous-green, minutely dotted with pale-coloured markings, otherwise glabrous, thickened at the nodes; 1st internode 3·5–4 mm. long; 2nd 9–11 mm.; 3rd 1·9–2·2 cm.

Leaves opposite, decussate or with the stipules appearing verticillate, sessile, with a distinct midrib prominent on the under side, but no other discernible venation in the fresh state, scabrous and deep green above, glabrous, and paler beneath with a cartilaginous, revolute margin, connate and together with the stipules forming a little cup round the stem; stipules one between each pair of leaves, subulate or linear-subulate, acute, revolute at the margin, similar in venation and other respects to the leaves but generally shorter, with their midribs as in the case of the leaves continuous with the angles of the stem, interpetiolar and connate.

First pairs of leaves lanceolate, longer and much broader than the stipules.

Second to fifth pairs linear-subulate, acute, similar to the stipules but slightly longer.

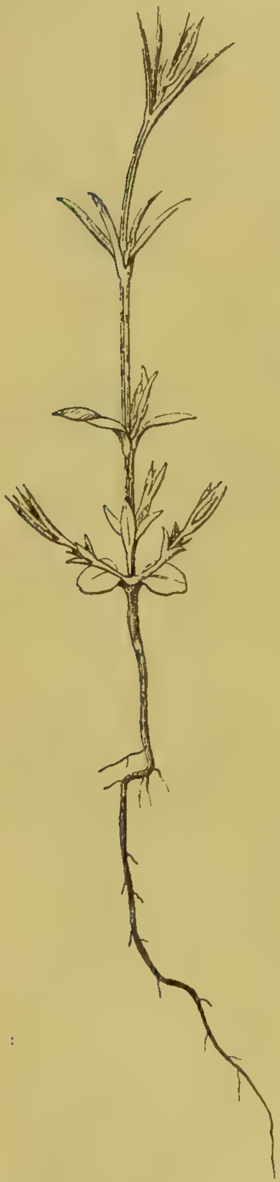

FIG. 443.
Crucianella ægyptiaca.
Nat. size.

Sherardia arvensis, *L.* (fig. 444).

Primary root long, slender, tapering, with numerous lateral fibres, all bright red.

Hypocotyl bent or procumbent, suddenly tapering downwards, glabrous, pale green, 7 mm. long.

Cotyledons large, foliaceous, fleshy, rotund, minutely emarginate, scabrous at the margin and minutely so all over the upper surface, trinerved and indistinctly reticulate, with the lateral nerves incurved and uniting with the midrib near the apex; lamina 9 mm. long, 8 mm. wide; petiole short, flattened above and shallowly grooved, often both directed to the upper side of the procumbent stem, so that the cotyledons may be fully exposed to light, about 1·5 mm. long.

Stem herbaceous, annual, procumbent, quadrangular; angles obtuse, smooth, glabrous, but in the adult state with deflexed prickles and pubescent; pale green; 1st internode 1 cm. long; 2nd 6·5 mm.

Leaves scabrously hairy on both surfaces, subfleshy in the seedling, light or dark green; petioles short, shallowly grooved above; stipules interpetiolar, foliaceous, equal to or smaller than the leaves and similar to them in most particulars.

First pair obovate, rounded, cuspidate; stipules similar, slightly smaller, one on each side of the stem, at all events in the first three pairs of leaves.

Second and third pairs similar, with stipules nearly the size of the leaves.

Ultimate leaves in pairs, lanceolate, acute, hairy on both surfaces; stipules four, similar and about the same size as the leaves, and revolute at the margin as are the leaves, especially when dry.

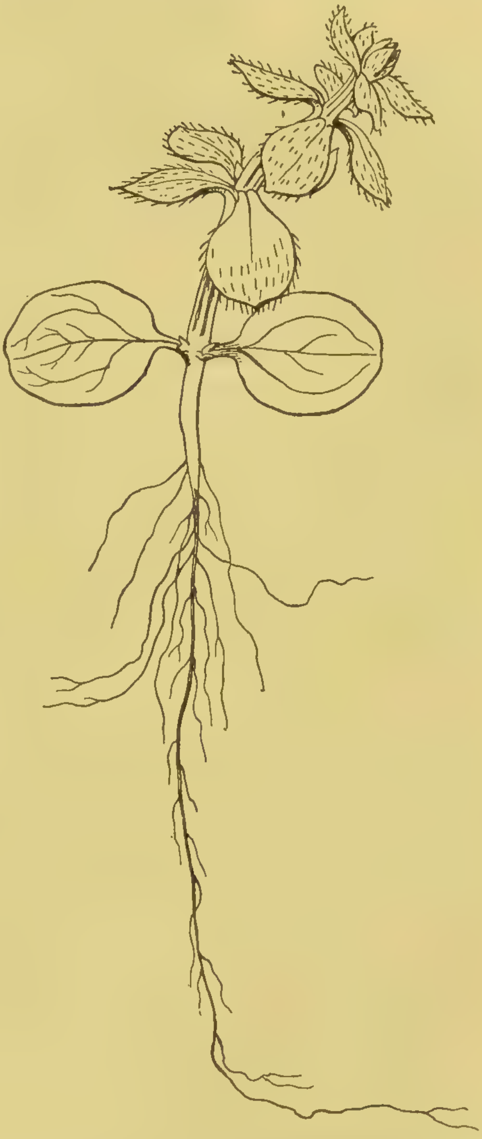

Fig. 444.—*Sherardia arvensis* × 2.

VALERIANEÆ.

Benth. et Hook. *Gen. Pl.* ii. 151.

Fruit and Seed.—As in the Compositæ, with which this Order has much affinity, the ovary is inferior, but it is three- instead of one-celled. One of the cells is perfect while the other two may be fertile or empty and represented by slender ribs which are sometimes appendiculate on one side. There is a solitary pendulous anatropous ovule in each fertile cell. The fruit is an inferior achene crowned by a many-rayed pappus-like calyx, or the latter is represented by a few-lobed cupular crown or minute inconspicuous teeth. The empty cells during the growth of the fruit remain unchanged or become drawn out upon one side. The solitary seed is comparatively large, conforming to the fertile cell of the fruit; and has a thin membranous testa. Endosperm is generally wanting, or reduced to a thin stratum. The embryo conforms in outline to that of the seed, and is straight with oblong cotyledons, and a rather elongated superior radicle. A very characteristic type of the Order is represented by Valeriana officinalis. The ovate, dorso-ventrally compressed fruit has only one fertile cell which is wholly occupied by the seed. It is surmounted by a many-rayed feathery pappus-like calyx, the segments of which are united at the base, forming a little cup which readily becomes disarticulated from the mature achene. The embryo conforms to the interior of the seed, but is nevertheless surrounded by a thin stratum of endosperm, and has plano-convex cotyledons. The fruit of Valerianella coronata is surmounted by a five- to six-lobed, cup-like calyx; but the segments are not feathery. That of V. Auricula is naked or furnished with very small teeth only.

Seedlings.—There is comparatively little variation in the form of the seed and embryo, so that the cotyledons seem to be pretty constant throughout the Order. They are shortly and broadly oblong, emarginate, petiolate, and trinerved. Valeriana officinalis may be regarded as typical as far as the cotyledons are concerned. The first leaf is rotund, slightly cordate at the base, and obtusely angled. The second is larger, five-nerved and dentate. The ultimate leaves are opposite and pinnatisect. The cotyledons of Centranthus macrosiphon (fig. 445) are broader and relatively shorter. The first five pairs of leaves are broadly ovate, serrate-dentate, and the ultimate ones scarcely differ. The first pair of Patrinia rupestris are spathulate, obtuse, and entire, while succeeding ones vary from lanceolate to elliptic, and are bluntly serrate.

The germinating seedling of Valerianella coronata (fig. 446) shows a remarkable contrivance for fixing the fruit or achene to the soil while the embryo makes its escape. The embryo swells up and bursts through the side of the fruit beneath the calyx-limb; then the radicle pierces through the latter, entering by the outer face and pushing through both sides enters the ground, thus pinning the fruit to the soil, while the cotyledons are pulled out in a comparatively short time and spread out to the light. At this stage they are shortly oblong, entire and sessile.

Valeriana officinalis, *L.*

Fruit an inferior achene, ovate, dorso-ventrally compressed, crowned with a conspicuous feathery, pappus-like calyx, which is articulated with the achene, one-nerved on the back and trinerved on the face; the two lateral nerves are filiform, and represent the two aborted cells.

Seed narrowly obovate, pendulous from the top of the cavity of the fertile cell, dorsally compressed, and otherwise conforming to the interior of the cell; hilum basal at the upper end of the seed; micropyle close to the hilum and superior; chalaza inconspicuous, apical.

Endosperm forming a thin film, surrounding the embryo, white.

Embryo straight, large, colourless, more or less filling the seed, and conforming to it in outline; cotyledons obovate-oblong, rounded at the apex, entire, tapering at the base; radicle short, stout, obtuse.

Seedling.

Primary root tapering, slender, fibrous.

Hypocotyl very short, terete, glabrous, 1·5 mm. long.

Cotyledons rotund or oblong, short, emarginate, petiolate, trinerved from the base and alternately penninerved upwards, glabrous, light green; lamina ·5–1 cm. long, 5–7 mm. wide; petiole rather broad, grooved above, dilated at the base and clasping, 8–11 mm. long.

Stem herbaceous, perennial portion very short; elongated when about to flower.

Leaves simple, radical and cauline, opposite (primary ones alternate), exstipulate, petiolate, glabrous in seedling, thinly hairy in the adult; petioles grooved above, semiterete, dilated and sheathing at the base.

No. 1. Rotund, subcordate at the base, slightly angled, but not cut, five-nerved at the base and suboppositely nerved upwards.

No. 2. Rotund, obtuse, cordate and five-nerved at the base, dentate with the nerves ending directly in the teeth.

Ultimate leaves ovate, or subtriangular in outline, pinnatisect, often unequal-sided, thinly hairy; segments alternate or sometimes opposite, frequently unequal on opposite sides of the midrib, lanceolate, obtuse, much narrowed at the base, coarsely, obtusely and irregularly serrate, three- to five-nerved longitudinally from the base, strongly reticulate with nerves sunk on the upper surface and prominent beneath.

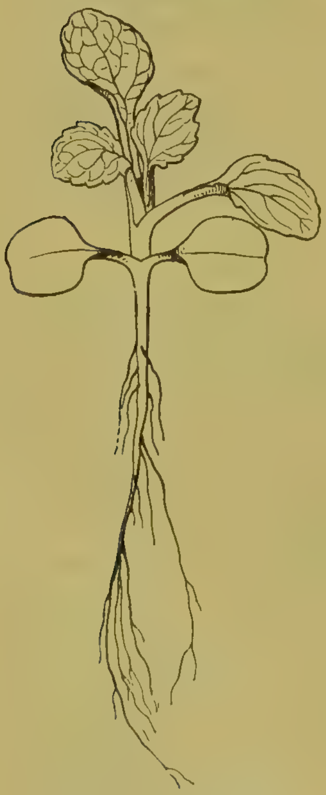

Fig. 445.
Centranthus macrosiphon.
Nat. size.

Centranthus macrosiphon, *Boiss.* (fig. 445).

Primary root stout, tapering, with fibrous lateral rootlets.

Hypocotyl mostly subterranean, pale or colourless, glabrous, terete, passing insensibly into the root.

Cotyledons broadly ovate and truncate, emarginate, or almost square, petiolate, glabrous, one-nerved; lamina 7·5 mm. long 7 mm. wide; petiole convex on the back, channelled above, about 6 mm. long.

Stem annual, developed when about to flower.

Leaves simple, radical and cauline, opposite, decussate, glabrous, alternately or suboppositely incurvinerved, reticulate, deep green;

petioles ridged or subcarinate beneath, rather acutely channelled above, dilated towards the base and subperfoliate.

First pair broadly ovate, obtuse, crenate.

Second pair ovate or oval, dentate.

Third, fourth, and fifth pairs broadly ovate, obtuse, more or less deeply, irregularly, obtusely, and mucronately dentate.

Valerianella coronata, *DC.* (fig. 446).

The radicle in germination usually bursts through the side of the fruit, and then pierces the limb of the calyx, thus fixing the fruit in the soil, as happens also in Scabiosa.

When free and above soil the cotyledons are shortly oblong, obtuse, entire, sessile and glabrous. One embryo only out of twenty-eight made its exit at the apex of the fruit, and from the centre of the calyx-limb. The radicle in this case pierced the calyx from its inner face outwards, and not from the outer face inwards, as is the usual method.

The fact of the radicle bursting through the side of the fruit is accounted for by two of the three cells of the ovary being small and empty, the third containing a seed is accordingly excentric, and therefore in germination its radicle naturally pushes through one side of the fruit.

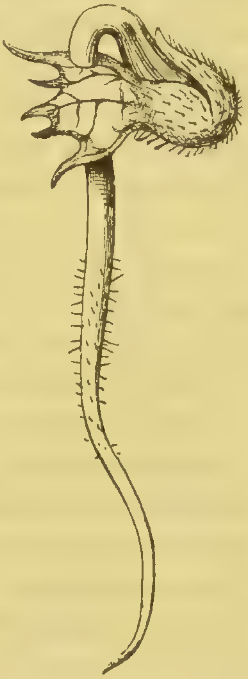

FIG. 446.—*Valerianella coronata*, × 4. Germination.

Valerianella Auricula, *DC.*

When the fruits have been moderately well covered with soil the embryo in most cases gets clear out of the fruit simply by the elongation of the hypocotyl.

The cotyledons are shortly oblong, obtuse, minutely emarginate, otherwise entire, sessile, convex above, concave beneath, glabrous, light green.

DIPSACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 157.

Fruit and Seed.—The ovary of the Dipsaceæ is simple, inferior and one-celled, with a solitary, pendulous, anatropous ovule; but in addition to the true calyx with which it is surmounted, each flower of the capitulum is surrounded by an involucel which completely encloses it, and appears like a second or a double calyx. The fruit is an achene surmounted by the persistent rarely deciduous calyx, and is completely enclosed by the involucel, also persistent and either surmounted by a lamina varying greatly in size, or truncate at the apex. The solitary seed, suspended from the apex of the cell, is covered by a thin membranous testa, and contains a thin or thick stratum of fleshy endosperm. The embryo is straight with a superior radicle and oblong or ovate cotyledons.

The pendulous anatropous ovule characteristic of the Order is represented by a vertical section of the ovary of Scabiosa atropurpurea (fig. 454, A) just after the expansion of the flower. For comparison with this Order the erect anatropous ovule of the Compositæ is represented in the two kinds of flowers of Chrysanthemum coronarium (fig. 454, B, C).

The reason for the ovule of the Dipsaceæ being pendulous and anatropous with a superior radicle has reference perhaps to the exit of the embryo during germination. The involucel is often or always more thickened and coriaceous, and often contracted at the base, making egress there difficult or impossible. The pericarp is thin and easily ruptured at the apex, or is actually open in cases where the calyx is deciduous. This idea is supported by the structure of the fruits in the following species, namely, Scabiosa palæstina (fig. 451), S. atropurpurea (fig. 454), S. australis (fig. 449), S. Gramuntia (fig. 453), S. graminifolia, S. Columbaria, S. Parnassi, S. arvensis, and S. caucasica (fig. 455); also by Cephalaria leucantha, C. rigida, Dipsacus sylvestris, D. ferox, and D. inermis.

A fruit with the calyx deciduous is represented by Dipsacus sylvestris with a characteristic embryo. Scabiosa australis (fig. 449) has a small funnel-shaped four-toothed calyx-limb, and its embryo is similar to that of Dipsacus sylvestris, but the seed contains a larger quantity of endosperm. The embryo of Scabiosa palæstina has broadly ovate cotyledons nearly dividing the endosperm into two equal portions. The fruit (fig. 451) is also notable both for the long slender beak into which it is prolonged at the apex, and the ten to twelve long, slender, feathery rays of the calyx. The involucel is also one of the most highly developed in the Order; its tube has eight strong ribs alternating with as many membranous portions actually perforated in the upper part; and the lamina is broadly expanded, flat or nearly so, membranous, and traversed by numerous nerves, excurrent as small teeth along the margin. The lower coriaceous portion would protect the seeds against drought, while the membranous lamina would serve to disperse the fruit.

Seedlings.—The structure and shape of the fruit and seed in this Order are very constant, varying chiefly in size, and so are the cotyledons as far as they have come under my observation. The prevailing form is broadly oblong, entire or emarginate, sessile, or tapering into a short broad petiole, and trinerved, but the lateral nerves are often indistinct. Most of them are narrow and linear or oblong when they emerge from the seed, but they generally increase considerably in size and sometimes undergo a little modification after germination by becoming emarginate, oblong-oval, somewhat obovate, or almost spathulate owing to their tapering into a broad petiole.

The involucel surrounding the fruit on the contrary varies considerably, and, together with the different modes of germination, offers a ready means of classifying most of the seedlings observed. The involucel of Dipsacus sylvestris is truncate at the apex, and the fruit crowned by a deciduous calyx. The seedling (fig. 447) has oval-oblong cotyledons, and the first six leaves are spathulate and crenate. D. ferox is another type of this group, but its mode of germination (fig. 448) is not common to all the species. The seedlings nearly always carry up the seed, fruit, and involucel on the tips of the cotyledons, which are rather broad and burst their investments during germination. Those of Scabiosa australis are linear-oblong, and do not burst the fruit and involucel during germination (fig. 449), and if the latter are fairly well covered with soil they are left in the ground when the embryo makes its exit. The cotyledons ultimately become broadly oblong and distinctly emarginate. The two primary leaves are broadly oval, and shortly petiolate (fig. 450). The fruit and involucel of this species closely resemble those of Dipsacus ferox, and its different behaviour during germination is accounted for by the fact that there is a small tooth-like projection on one side of the base of the hypocotyl (fig. 449, B), and this, fixing itself in the small rim or lamina of the involucel, holds it down while the cotyledons are drawn out.

A second distinct type is represented by Scabiosa Gramuntia (fig. 453). The involucel has a well-developed cup-like lamina, and the radicle on germination pierces it, and holds it firmly to the soil by means of a thickening at the base of the hypocotyl while the latter on lengthening draws out the cotyledons. This thickening is symmetrical or equal all round, not unilateral as in S. australis. The fruit of S. Columbaria is rather thicker and shorter, while the cotyledons are also shorter, but in no other respect do they or the germinating seedling differ from S. Gramuntia.

In the third type the radicle of the germinating seedling pushes through the sides of the involucel, beneath the thickened rim at the base of the lamina. The base of the hypocotyl also has a symmetrical, annular thickening as in the second group. The involucel of Scabiosa palæstina (fig. 451) is salver-shaped and attains a much greater size than that of any other species observed. The lamina is particularly large, membranous and traversed by straight radiating nerves excurrent at the margin, forming a deeply fringed border. Beneath the thickened rim at the base of the lamina are numerous perforations, through one of which the radicle finds its way, fixing the fruit to the ground. The cotyledons ultimately become obovate-spathulate and slightly emarginate. S. graminifolia has likewise a perforated involucel. The thickening of the hypocotyl is well shown by S. atropurpurea (fig. 454, D). The cotyledons are oval-oblong and shortly petiolate. The first four pairs of leaves vary from spathulate to oblong or elliptic, while the fifth to the seventh pairs inclusive are pinnatipartite. The lamina of the involucel is smaller than in S. palæstina, but there are no perforations in any part of it. The radicle easily pushes its way through the membranous portions at the sides between the greatly thickened ribs of the involucel, thus demonstrating the economy of the unequal thickening. A peculiar anomaly presents itself in the germinating seedling of Scabiosa caucasica (fig. 455). The base of the hypocotyl is more or less thickened as in the other species, but it generally if not always pushes itself right through one or other of the membranous portions of the involucel, and the thickening appears therefore to be now functionless so far as its original purpose is concerned. The lamina of the involucel is reduced to a rim crowned by numerous coarse bristle-like segments. The seedling is different from all others I have noticed. The hypocotyl remains short, the oblong entire cotyledons are sessile, and the first pair of leaves are oblanceolate and entire. The radical leaves of the adult plant are spathulate, entire and decurrent upon the long petiole, but most of the cauline ones are pinnatisect with linear segments.

The seedlings of S. rutæfolia (fig. 456) exhibit a similar evolution of the foliage to S. atropurpurea, but I have not seen either the fruit or germination. Furthermore the seedlings are dimorphic; some have opposite leaves with the first three pairs spathulate and bluntly serrated near the apex, and the fourth pair more or less lobed, while others have the leaves in whorls of three. Those of the first three whorls resemble the leaves of the first type, but in the fourth and fifth whorls they are irregularly and deeply pinnatifid. The cotyledons of S. maritima are obovate-oblong and emarginate, while the first pair of leaves are oval or obovate.

It will be noticed that in all of the above-mentioned seedlings the cotyledons are sessile on leaving the seed, but afterwards petiolate, Scabiosa caucasica alone forming an exception.

Dipsacus sylvestris, *L.*

Fruit an achene enclosed in a tetragonal involucel, having an intermediate set of smaller ridges, one on each face, free from the involucel, oblong, apex conical, base obtuse, crowned with the ultimately deciduous calyx and marked longitudinally with eight ridges; pericarp extremely thin and membranous except on the ridges.

Seed oblong, conical at the tip, conforming to the outline of the ovary, which it completely fills; testa extremely thin and membranous; hilum at the extreme upper end of the seed and inconspicuous.

Endosperm copious, fleshy, white, surrounding the embryo.

Embryo straight, large, nearly equal in length to the seed; cotyledons oblong, obtuse, entire, plano-convex, embedded in the endosperm which is thinnest at the edges of the cotyledons and the radicle; radicle very stout, slightly and suddenly narrowed at the tip which is close to the apex of the seed, about one-third as long as the cotyledons.

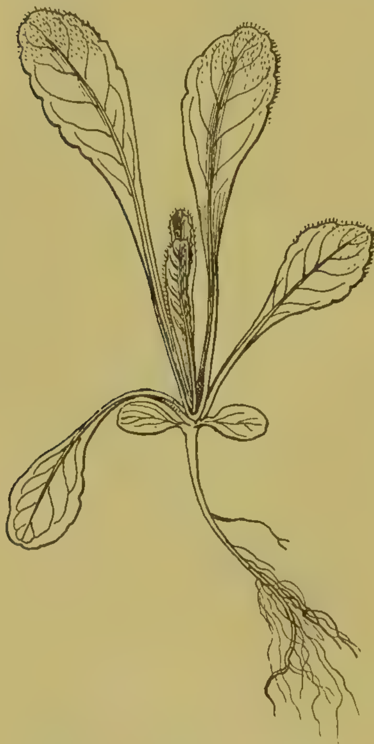

Fig. 447.—*Dipsacus sylvestris.* Half nat. size.

Seedling (fig. 447).

Primary root stout, long, tapering, with numerous lateral fibres, biennial.

Hypocotyl subterranean, stout, colourless, about 1 cm. long.

Cotyledons subfoliaceous, glabrous, petiolate; lamina oval-oblong, entire or minutely emarginate, 12 mm. long, 7 mm. wide; petiole flattened, 7 mm. long.

Stem herbaceous, erect, and elongating the second year when about to flower.

Leaves simple, radical and ultimately cauline, opposite, exstipulate, radical ones petiolate, cauline sessile, and connate by their bases, hairy on both sides, pale green, nerved and reticulate with ascending and subincurved nerves, entire or toothed; petioles rather broad, channelled, slightly winged upwards.

First pair spathulate, obtuse, subentire or shallowly and obsoletely crenate.

Second pair similar, shallowly crenate with long petioles.

Third pair oblong-spathulate, obtuse, shallowly crenate, decurrent on the long petioles.

Ultimate leaves cauline, sessile, connate by their broad bases, oblong-lanceolate, obtuse, irregularly and obtusely toothed except at the base and tip, penninerved with numerous subparallel nerves, glabrous, spiny along the midrib beneath with recurved prickles; teeth deepest and coarsest about the middle of the leaf.

Dipsacus ferox, *Lois.* (fig. 448).

Germination.—The radicle emerges at the apex of the fruit through the mouth of the involucel. Numerous root-hairs are produced on the radicle and the base of the hypocotyl.

The fruit enclosed in the involucel is then usually carried up with the cotyledons (fig. 448), which by widening have split the involucel along one side (about the second day after their first appearance above ground).

Whether the fruit and involucel are carried up or not, the energy of the expanding cotyledons is generally, if not always, able to extricate them from such investments, and the cotyledons spread out to the light.[1] They are oblong, obtuse, entire with a slightly prominent, apical, colourless tooth, narrowed into a short petiole, with a few alternate, ascending, obscure, lateral nerves, glabrous, pale green but soon becoming deep green. Hypocotyl glabrous.

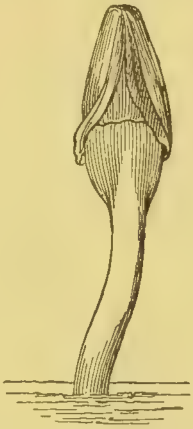

Fig. 448.—*Dipsacus ferox.* The fruit enclosed in the involucel carried up by the cotyledons in germination, × 3. (Second day after first appearance above ground.)

Scabiosa australis, *Wulf.*

Achene conical-oblong, terminated by the small funnel-shaped, four-toothed lamina of the calyx, and surrounded by an involucel, thin-walled, membranous, ribbed, glabrous; involucel flask-shaped, with a narrow neck and funnel-shaped mouth, strongly eight-ribbed, with the ribs obtuse and the alternate ones smaller, remaining as a covering to the fruit till its germination and decay.

Seed oblong, obtuse at the lower end, narrowed to a short obtuse point at the upper end, closely conforming to the interior of the achene; hilum and micropyle superior, contiguous; testa thin, membranous, very pale-coloured; chalaza apical and inferior.

Endosperm copious, fleshy, white when moist.

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[1] Ninety-eight to a hundred per cent. of the seedlings carry up the fruit and involucel during germination.

Embryo comparatively large, but falling short of the endosperm, straight, axial, yellowish; cotyledons plano-convex, oblong, obtuse, entire, sessile, lying in the broader plane of the seed; radicle oblong, obtuse, with a slightly turbinate point, about half as long as the cotyledons, lying close to the upper end of the seed.

Germination and Seedling (figs. 449, 450).

The achene closely occupies the interior of the involucel, so that in germination the radicle gets outside immediately and pushes down straight into the soil for a considerable depth, at the same time giving off numerous root-hairs. There are no perforations below the rim of the involucel, nor are they needed, on account of the shortness of the neck and the small lamina.

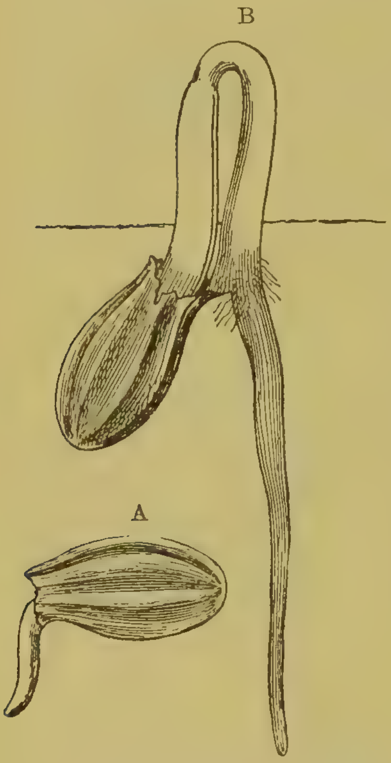

Fig. 449.—*Scabiosa australis*, × 6. Commencement of germination.

If the involucel is fairly well covered with soil the cotyledons, after the long radicle has established itself, are easily and readily pulled out clear of the seed and its investments. The cotyledons in this species are not very broad, because the seed itself is not very thick.

The base of the hypocotyl has a thickened projecting ledge which presses against the rim of the involucel and pins it to the earth while the arching upper part grows upwards and extricates the cotyledons (fig. 449, B).

About two days after germination the latter become free, and are linear, obtuse, emarginate, and tapering slightly to the base.

About four days after germination they are oblong, obtuse, much broader and more distinctly emarginate, tapering at the base into a short petiole, with a distinct midrib, and glabrous.

The cotyledons ultimately become broadly oblong, distinctly emarginate, cuneate at the base, petiolate, trinerved at the base, or for the greater part of their length, and alternately nerved upwards (the venation is best seen on the under surface), glabrous, bright green above, paler beneath; petiole flattened above, very slightly connate at the base.

The first pair of leaves are broadly oval, slightly emarginate, suddenly narrowed at the base into short, channelled petioles, obscurely alternately incurvinerved on the upper surface, bright green and shining, but distinctly nerved underneath and paler, glabrous.

On the upper side of the cotyledon, close to the edge of the sinus, are about three large water-pores in connection with the vascular system at the apex of the midrib. The smaller cells of the tissue in that region seem to determine the slower rate of growth resulting in the emargination of the cotyledons.

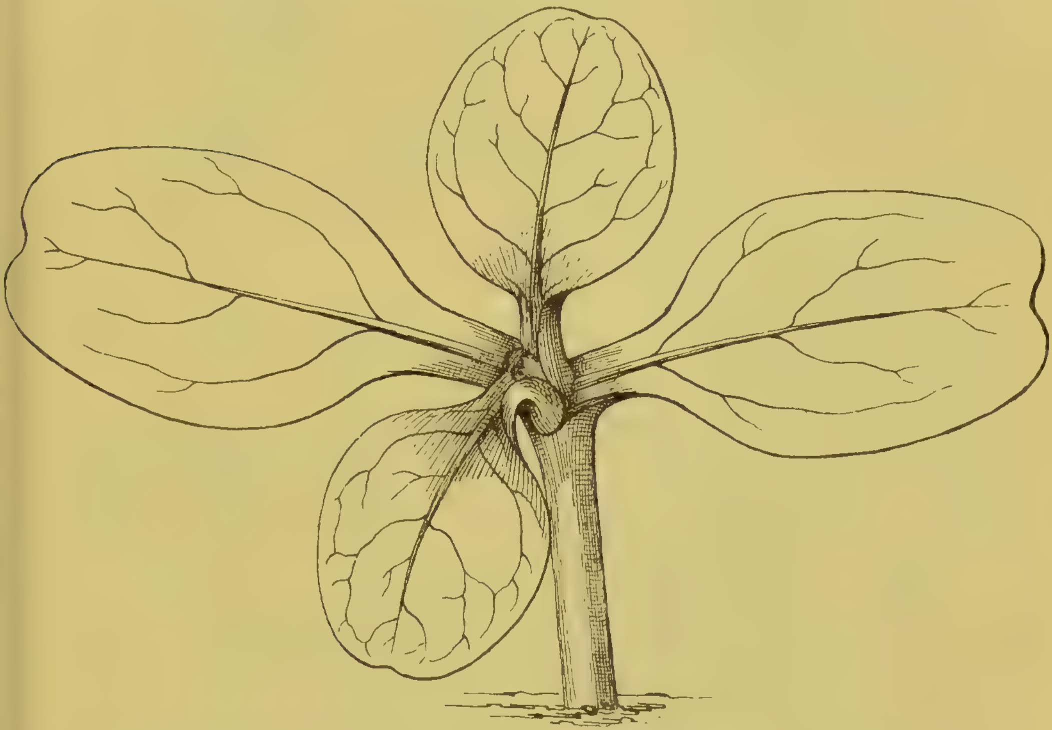

FIG. 450.—*Scabiosa australis*, × 6. Seedling, forty-four days after germination.

Scabiosa palæstina, *L.* (fig. 451).

Achene closely surrounded and enclosed in an involucel, thin-walled, membranous, pale-coloured, eight-ribbed longitudinally, pubescent, produced into a long slender beak or neck, expanding into a short cup from which spread ten to twelve long feathery rays.

Involucel turbinate, longitudinally eight-ribbed, perforated with as many openings near the top, above which it expands into a broad, nearly or quite flat, many-ribbed, scarious lamina, with the ribs exserted as marginal teeth, more or less hairy.

Seed broadly ovoid, conforming in outline to that of the achene in its lower and thickened part; testa membranous; hilum basal, close to the base of the beak of the ovary.

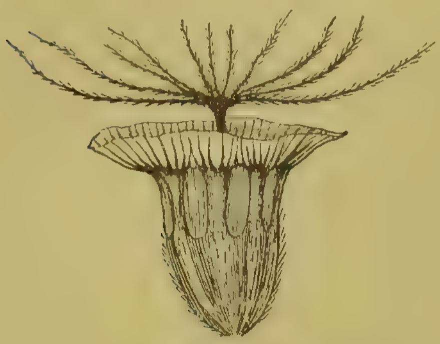

Fig. 451.—*Scabiosa palæstina.* Involucel, containing fruit, × 3.

Endosperm copious, fleshy, white, forming a very thin layer at the edges of the cotyledons, but much thickened at their backs.

Embryo large, straight, nearly equal in length to the endosperm, and nearly as wide in the plane of the cotyledons, pale yellow; cotyledons obovate, or broadly oval, obtuse or rounded at the end, entire, suddenly narrowed into the radicle; radicle short, stout, turbinate, obtuse, lying in the conical base of the seed, and in the basal part of the beak of the ovary.

Germination (fig. 452).

The involucel of this species is very large, and plays an important part in the economy of the plant.

The limb is salver-shaped, membranous with numerous radiating nerves running out at the margin and forming a deeply fringed border. Immediately beneath the rim are numerous perforations between the strong ribs. The radicle in germination always emerges through the opening at the apex of the involucel, easily rupturing the thin and membranous pericarp.

If the involucel with the fruit is placed mouth downward in the earth (an unnatural position), and but lightly buried or lying on the surface of the soil, the whole may be carried up with the cotyledons. If, on the other hand, the involucel is lying on its side or with its mouth upwards, the radicle proceeds freely a short distance, and then turning downwards makes its exit through one of the openings, and grows to a great depth straight down into the earth. Some seedlings in the course of germination showed a radicle measuring 2–4 cm. in length, seven days from the time of sowing. This conduct of the radicle is of great importance in a country with the dry climate of Syria, where the plant is indigenous, not only in its depth of penetration, but in effectually fixing the involucel, pericarp, ovary and testa of the seed to the earth while the cotyledons emerge and rise up free.

The cotyledons afterwards become more or less spread out, oblong, petiolate and tapering into the petiole, showing indistinctly on each side of the midrib one or two subopposite or alternate nerves, and faintly emarginate at the apex.

Ultimately they are obovate-spathulate, shallowly emarginate, petiolate, fleshy, glabrous, with a distinct midrib, and a few alternate, ascending nerves, best seen on the under surface. Hypocotyl glabrous.

Scabiosa Gramuntia (fig. 453).

The radicle makes its exit at the upper end of the fruit, and then generally pierces the lamina of the involucel, fixing it to the soil by the thickening at the base of the hypocotyl, which then pulls the cotyledons out (fig. 453).

These, as soon as they have made their exit from the fruit and spread out to the light, are narrowly oblong, obtuse, entire, sessile, glabrous, narrowed to the base, pale green, with an evident midrib, and about two alternate, incurved, indistinct nerves on each side.

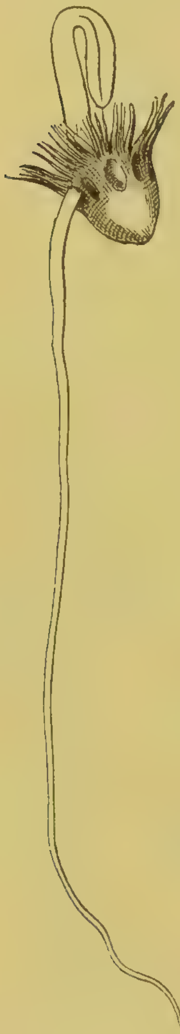

FIG. 452.—*Scabiosa palæstina*, × 2. Germination.

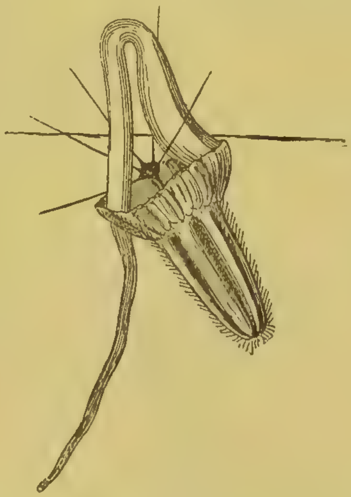

FIG. 453.—*Scabiosa Gramuntia*, × 4. Germination.

S. atropurpurea, *Wulf.*

Germination and Seedling (fig. 454, D).

The sides of the involucel are moderately thick, but the middle

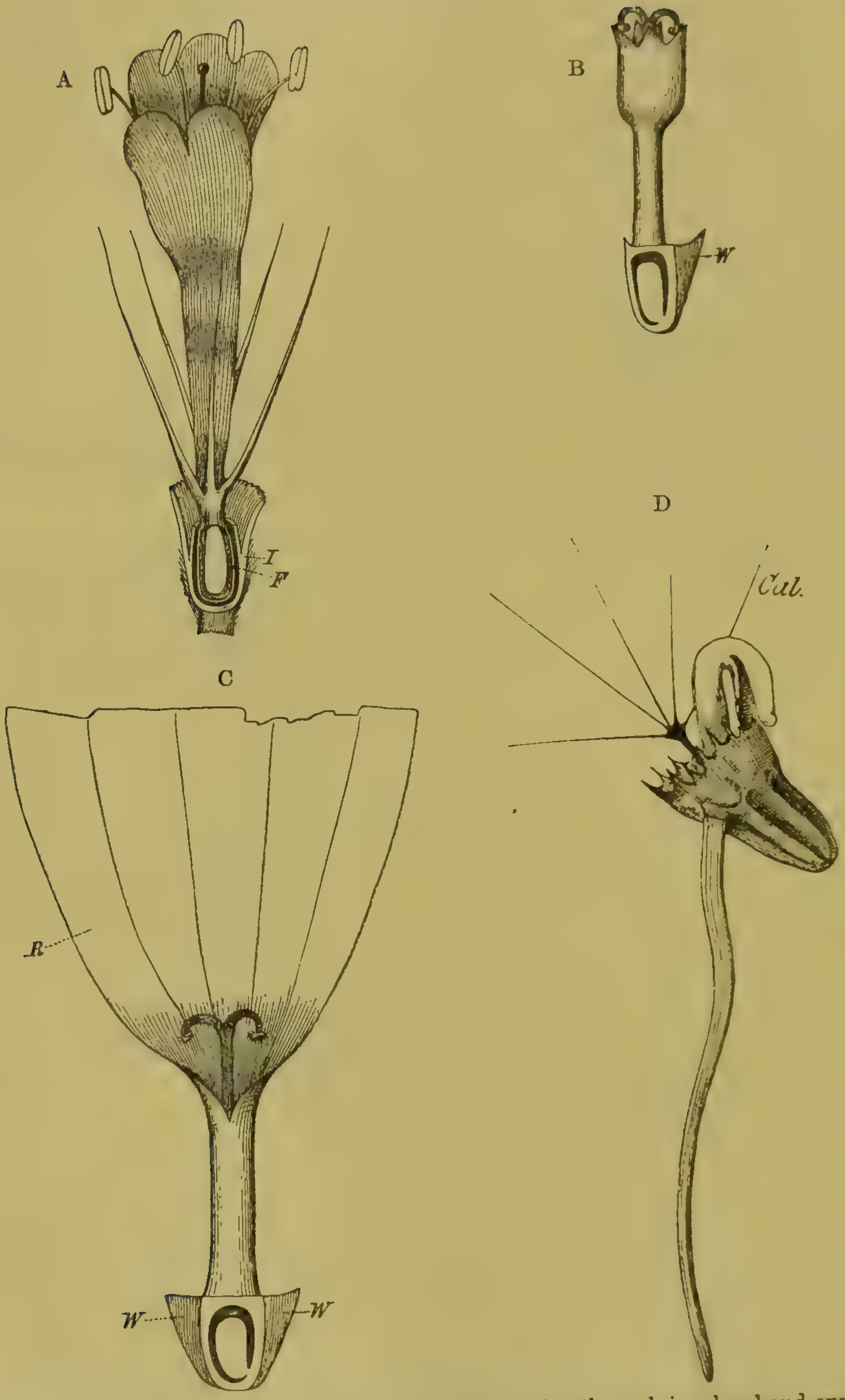

Fig. 454.—*Scabiosa atropurpurea*. A, vertical section through involucel and ovary, × 5: *I*, involucel; *F*, wall of ovary. B, *Chrysanthemum coronarium*, vertical section through ovary of hermaphrodite floret, × 5: *W*, wing. C, vertical section through ovary of female floret, × 5: *W W*, wings; *R*, ray floret with part of ligulate corolla cut away. D, *Scabiosa atropurpurea*, germination, × 3: *Cal*, the five segments or bristles of the calyx.

layer consists of woody or prosenchymatous tissue, and the base is thicker. Above the lamina of the involucel the woody and compact tissue thins out and its place is taken by parenchyma, and in the young state very watery-looking tissue. The pericarp is thin and contains but a moderate amount of vascular tissue, and is therefore easily burst through when decaying by the germinating embryo.

The radicle emerges at the apex of the fruit, and immediately turns towards the earth, where it comes in contact with the involucel and pushes through one of the thin membranous parts between the ridges. The hypocotyl has an annular thickening at its base by which the fruit is held down when the radicle enters the ground. The hypocotyl then elongates and pulls the cotyledons out of the fruit as shown in the accompanying sketch (fig. 454, D).

When the cotyledons have spread out to the light about two days after germination, they are oblong or oval, obtuse, entire, narrowed slightly to the base, sessile, glabrous, and light green ; the hypocotyl is glabrous and colourless.

Ultimately the cotyledons are oval-oblong, obtuse, shortly petiolate, 1·3 cm. long including the petiole, 7 mm. wide.

Leaves simple, cauline, opposite, exstipulate, petiolate, or the upper sessile, sparingly hairy; petioles channelled above, dilated, amplexicaul and connate at the base.

First pair obovate-spathulate, crenate-serrate.

Second pair similar, but much larger.

Third pair spathulate-elliptic, obtuse, attenuate at the base, serrate.

Fourth pair elliptic-oblong, coarsely incise-serrate.

Fifth pair oblong, pinnatipartite ; segments oblanceolate, acute, entire or slightly toothed.

Sixth and seventh pairs oblong, pinnatipartite ; segments long, linear, acute, entire or sparingly toothed.

Scabiosa caucasica, *M. Bieb.* (fig. 455).

The radicle emerges at the apex of the fruit and, immediately turning towards the earth, penetrates the thin membranous part of the involucel between the thickened ridges directly beneath the thickened rim. The radicle is long and strong, fixing the seedling firmly in the soil. The base of the hypocotyl is thickened as in the other species described, but this thickening seems generally if not always to push through the involucel and is consequently functionless.

The cotyledons are gradually pulled out of the fruit by the energy of the growing hypocotyl.

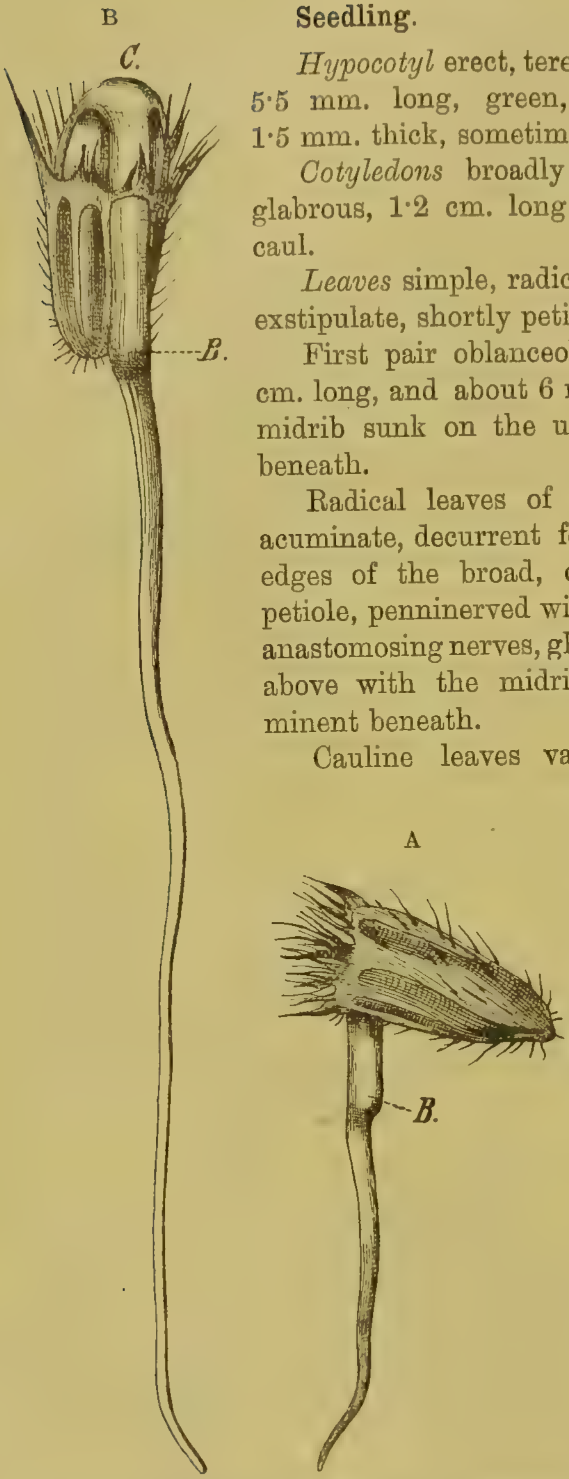

Fig. 455.—*Scabiosa caucasica*, × 3. A, commencement of germination. B, day after commencement; *B*, thickened base of hypocotyl; *C*, cotyledons.

Seedling.

Hypocotyl erect, terete, glabrous, herbaceous, 5·5 mm. long, green, reddish at the base, 1·5 mm. thick, sometimes subterranean.

Cotyledons broadly oblong, entire, sessile, glabrous, 1·2 cm. long, 9 mm. wide, amplexicaul.

Leaves simple, radical and cauline, opposite, exstipulate, shortly petiolate, penninerved.

First pair oblanceolate, entire, glabrous, 4·1 cm. long, and about 6 mm. wide, with a strong midrib sunk on the upper side and prominent beneath.

Radical leaves of adult plant spathulate, acuminate, decurrent for some distance on the edges of the broad, channelled, pale-coloured petiole, penninerved with ascending and slightly anastomosing nerves, glabrous, ciliate, deep green above with the midrib sunk above and prominent beneath.

Cauline leaves variable, like the radical ones, but the greater number pinnatipartite, with linear, acuminate, segments, sessile; terminal lobe or segment large, lanceolate, acuminate, entire or slightly cut at the base. Otherwise like the radical leaves.

Scabiosa rutæfolia, *Vahl* (fig. 456).

Hypocotyl subterranean.

Cotyledons oblong, obtuse or emarginate, one-nerved, tapering into a short petiole, glabrous, 1·3 cm. long including the petiole, 6 mm. wide.

Stem herbaceous, erect, terete, hairy in lines decurrent from the basal edge of the petioles, purplish; 1st internode undeveloped; 2nd 2 mm. long; 3rd 6 mm.; 4th 2 cm.; 5th 1·7 cm.

Leaves opposite or verticillate (in threes), simple, cauline, exstipulate, petiolate, ciliate and sparsely hairy. When the leaves are verticillate those of the first whorl are spathulate, obtuse, slightly serrate near the apex, gradually narrowed into the slender channelled petioles.

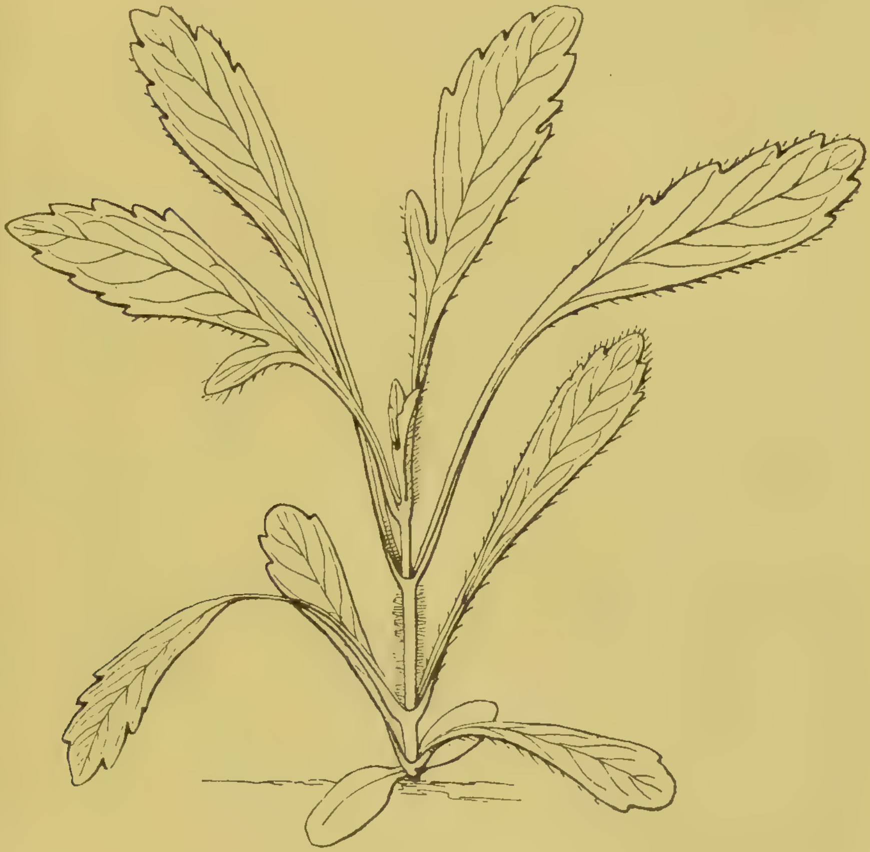

FIG. 456.—*Scabiosa rutæfolia.*
Nat. size.

In the second whorl they are similar but larger.

Those of the third whorl are oblanceolate, obtuse, serrate along the upper third, narrowed gradually into slender petioles.

In the fourth whorl they are pinnatipartite with 1–2 segments on each side, and a terminal one; segments oblanceolate, obtuse, smallest towards the base and the terminal one largest.

Those of the fifth whorl have two linear segments at each side, and a terminal, larger and oblanceolate one, decurrent with a narrow margin nearly or quite to the base.

In seedlings with opposite leaves the first pair (as shown in fig. 456) are spathulate, obtuse, and slightly serrate near the apex.

The second pair are oblanceolate, serrate near the apex.

The third pair are oblong-oblanceolate, incise and rather obtusely serrate, gradually narrowed into long slender petioles, channelled on the upper side.

The fourth pair are similar, but have an oblong, obtuse, entire lateral segment near the base.

COMPOSITÆ.

Benth. et Hook. *Gen. Pl.* ii. 163.

Fruit and Seed.—The ovary is inferior and syncarpous, consisting of two carpels, as appears from the two divisions of the style, but it is one-celled and contains a solitary, basal, erect, anatropous ovule with an inferior micropyle. The fruit is an achene, dry, rarely fleshy, crowned with an exceedingly varied persistent pappus or calyx in different genera, or sometimes the pappus is entirely absent. The solitary seed is erect and straight or curved in conformity with the size and shape of the cavity of the achene. The testa is membranous, rarely thickened and generally free from, but sometimes adherent to, the walls of the ovary. No endosperm is present; and the embryo occupies the whole interior of the seed to which it conforms. The cotyledons are semiterete or flattened or rarely slightly convolute, and although frequently more or less curved in conformity with the achene, they are seldom unequal in length, as occurs for instance in Coreopsis Atkinsoniana. The radicle seems always to be short and inferior.

Exceptional cases occur in Balbisia where the cotyledons are conduplicate, in some species of Robinsonia; and in some species of Gymnolomia, Sclerocarpus, Baltimora, and possibly in a few other genera where they are concave or channelled on the inner face, or in cases where they are unequal, the apex of the longer one is inflexed.

The seeds observed may be most readily classified according to the shape of the embryo, and that part of the achene which contains it, regardless of the numerous modifications of the pappus or calyx which have no direct bearing upon this. One of the simplest types of the embryo is that seen in the species of Senecio. The fruit of S. erucæfolius is short oblong-cylindrical and suddenly narrowed or contracted at the base. It is surmounted by a pappus of long scaberulous hairs, and the embryo conforms to the internal cavity. The achene of Senecio cruentus is covered with small papillæ in numerous apparently double lines. The fruit and embryo of Odontospermum spinosum are more decidedly obovoid, and the pappus consists of a few, short, stout teeth. The achenes of Lonas inodora and Moscharia pinnatifida (fig. 485) are also short and obovoid, but they are more or less compressed with the embryo conforming. The cotyledons of the latter are emarginate, owing apparently to the more rapid growth of the tissues on each side of the apex. The pappus consists of unequal hairs placed obliquely on the achene which is enclosed by a large and curious bract.

Many species belonging to different natural groups agree in possessing narrow spathulate, linear or cylindrical fruits with correspondingly narrow and elongated embryos. The achene of Ursinia speciosa (fig. 478) is cylindrical, slightly curved and narrowed towards the base. The pappus consists of five oval or ovate, entire, hyaline scales. The fruit of Tragopogon minor is cylindrical, slightly curved, more or less ridged and prolonged at the apex into a long slender beak, bearing the pappus. That of Rhagadiolus stellatus is also elongated, terete or compressed. The fruits of Dahlia variabilis, Lasthenia glabrata and Layia platyglossa are spathulate, more or less compressed and narrowed to the base. Those of Bidens humilis are linear, obtusely tetragonal, and much elongated with a corresponding embryo. The pappus consists of two horn-like processes. The fruits of Tagetes erecta, T. patula and others, are thin, and much compressed like those of Dahlia.

The species of Helianthus and perhaps some ot allies may constitute another group characterise large seeds and oblong-obovate, obtusely tetrag which in transverse section appear of rhomboid ou cotyledons of Helianthus annuus are broadly obl convex, and entire, and suddenly narrowed in radicle. Those of H. cucumerifolius differ in t smaller size, and in being slightly emarginate, somet to a depression at the apex of the achene.

The species of Coreopsis are notable for their tened, winged or variously but unequally thicke The winged condition is well shown in Coreopsis (fig. 462), the fruits of which are obovate or, with often suborbicular. The latter sometimes form a border to the lateral margins of the achene, but are interrupted or broken in various places. T is broadly oval with a very short radicle. T C. Atkinsoniana (fig. 460) is similar in outlin wings are absent, and instead of being biconvex cavo-convex owing to the inrolling of the thicken The embryo is somewhat curved longitudinally short roundly obovate cotyledons. C. filifolia differs markedly from either, in the seed being sub and slightly compressed, with the fruit greatly on the dorsal surface by means of cortical or blunt protuberances. The embryo is curved cotyledons.

The relative size, shape, and number of fruits tacle have all a direct bearing upon one another.

For instance, if the receptacle is narrow and bear but a few fruits, or if they happen to be num are very broad and winged, and, notwithstanding the and elevated character of the receptacle, compar few reach maturity. On the other hand, the distribu the fruits which do mature is aided by wing-like d ments of their edges. These facts are borne out by species examined, of which a description is given Another very noticeable fact is that a larger proport the fruits of annual species seem to reach maturity than case of perennials. The fruits of Bidens humilis and cantha are very narrow, and a large percentage of them maturity. Both are annual species, and the barbed cha of the pappus of some, including B. leucantha, is well a to ensure the distribution of the fruits.

The polymorphic forms of the fruits of Calendula e the same receptacle are very remarkable. In C. offi at least three very distinct types may be noted. Two o rows round the margin of the receptacle consist of elongated, curiously constructed, curved achenes, muri the back, often beaked at the apex and produced into a like process near the base on the inner face. The mid of fruits is furnished with broad wings involute at th gin, but neither beaked at the apex nor produced into at the base. Those about the centre of the recepta greatly incurved, often forming a complete ring, an narrow wings involute at the margin. Transvers tions of each series give a good idea of the structure three different forms. The embryo is cylindrical in al cases, curved, gradually tapered into the radicle, and wise similar except that the middle series is not so st curved.

It would seem as if we have here three devices fo fruit to the ground while the elongating hypocotyl extricates the cotyledons. In all three cases the radicle emerges at the base of the fruit which splits longitudinally by three valves, thus facilitating the exit of the embryo. The splitting of the fruit is brought about by the force of the rapidly swelling cotyledons. When the latter have got quite clear, they are spathulate-oblong, obtuse, entire and tapered to the base.

The fruits of Calendula pluvialis are dimorphic. Those at the periphery of the receptacle are broadly obovate or suborbicular, flattened, and smooth with broad flat wings. The embryo is straight in conformity with the fruit, and has linear-oblong or spathulate cotyledons. The other fruits are obovoid, not flattened, and muricate all over the surface. In C. hybrida the fruits are also dimorphic. The outer ones of the receptacle are obovate, much flattened with broad flat wings. Those of the centre of the receptacle are obovoid, slightly curved or straight, trigonous and toothed on all the three angles. The embryo is straight or nearly so in both cases with linear-oblong rather fleshy cotyledons. The fruits of C. gracilis are also somewhat dimorphic judging from the specimens observed. One kind is curved so as to form a complete annulus, and it is muricate in transverse wavy ridges. In the other case the annulus is not complete and the muricate ridges on the back are nearly obsolete.

There are three or four different forms of fruit in C. algarbiensis. Those on the periphery of the receptacle are oblong, straight or slightly curved, not winged but prolonged at the apex into a slender beak. The next series consists of fruits with narrow, strongly involute wings, muricate along the back with three rows of teeth, and coiled so as to form a complete annulus. In a third set of fruits the annulus is less complete, the wings are absent, and the back is merely rugose in transverse obtuse ridges. In the fourth or central series the fruits are very small, apparently imperfect, and not completely annular.

Seedlings.—The prevailing type of the cotyledons in the seedling stage is spathulate, a shape due to that of the seed, which in turn conforms strictly to the interior of the fruit.

Thus in some species the cotyledons are linear, sometimes of considerable length; in others the fruits widen until we have obovate cotyledons; while in a few cases they are ovate and pointed. We may comprise in the first division those which are relatively short in proportion to their width. This is fairly well represented by Chrysanthemum segetum, which has spathulate-oblong, obtuse, short, sessile cotyledons, slightly connate at the base forming a little cup round the plumule or axis. This latter character is widely prevalent amongst the Compositæ. The primary leaves are oblong, and more or less deeply pinnatifid and toothed. C. carinatum (fig. 472) differs chiefly in the first two leaves being narrower and pinnatifid with oblong, entire segments. The seedling of Anacyclus radiatus is much taller with all its parts more elongated. The two primary leaves are divided to the midrib with bifid and a few entire segments. Achillea Millefolium (fig. 470) has shorter cotyledons and the first two leaves are opposite, tapering into a petiole, with one or two teeth on each side above the middle. The cotyledons of Matricaria Parthenium are also small. The first leaf is small, spathulate, and entire or nearly so, while the second is cuneate and trifid. The other leaves show great increase in size and an interesting evolution as far as division is concerned. The division of the foliage of Matricaria globifera is even more complicated, with the ultimate segments linear. The first two leaves are small, spathulate-cuneate and five-toothed. The first two of Matricaria nigellæfolia (fig. 473) are opposite, narrowly lanceolate and entire, the third is cuneate, trifid, alternate, and the fourth pinnatifid. The cotyledons are considerably elongated. Lonas inodora (fig. 469) has a superficial resemblance to the last, but the cotyledons are short and oval, while the first three pairs of leaves at least are opposite, the first pair being lanceolate and entire, followed by two cuneate and trifid pairs.

Another group of plants belonging to the same extensive tribe as the last, namely the Anthemideæ, has the cotyledons short or narrow and small. Those of Anthemis sp. (fig. 471) are linear-oblong and 5 or 6 mm. long. The first pair of leaves are pinnatisect with linear segments and very different from the first pair of A. mixta, which are linear, entire, long, slender, and narrower than the cotyledons. The third leaf of the latter is pinnatisect and alternate. The cotyledons of Artemisia Mutellina are linear-spathulate, and the first four or five leaves are linear and entire. Strikingly different is A. annua, having oblong cotyledons about 2·5 mm. long, and the first two leaves short, cuneate and tri-fid or -dentate. The ultimate leaves are tripinnatisect with toothed segments. The first two of Pentzia virgata are linear, entire, and slightly broader upwards, while the cotyledons are spathulate-oblong and 3–4 mm. long. The first pair of leaves of Cenia sub-heterocarpa are linear, slender, entire, followed by three other pairs which are more or less divided. Cotula coronopifolia is somewhat similar in its early stages, but only the first pair of leaves are linear and entire, and the cotyledons are narrowly spathulate.

A group of plants belonging to several other tribes may be mentioned here on account of the similarity of the cotyledons to those of Chrysanthemum and its allies. The shortly oblong cotyledons of Brachycome iberidifolia (fig. 457) very nearly resemble those of Achillea Millefolium. The first two leaves are linear and entire, while the third has one or two teeth on each side near the apex. The first three pairs of leaves of Charieis heterophylla are oblong or spathulate-oblong, sometimes pinnatifid and hairy, while the cotyledons are oblong or often almost obovate. The same, or nearly the same, characters apply to Madia corymbosa, except that the seedling is stronger, or the hypocotyl longer. Lactuca lævigata (fig. 488) presents no affinity with the above, but the cotyledons are spathulate, tapering into a short petiole. The first leaf is oval with a long petiole, the second lanceolate with a much longer petiole, while the third leaf is lyrate-pinnatifid with the lateral segments slender.

A second type of short cotyledons is represented by Bellis perennis (fig. 458). The cotyledons are rotund or orbicular, petiolate, emarginate, or less frequently entire. As in the first type the petioles are more or less connate at the base. The two first leaves are rotund and nearly or quite entire. Around this type a number of species belonging to widely different tribes may be grouped. The cotyledons of Rudbeckia serotina are shortly petiolate, while the first three leaves are ovate or lanceolate, and trinerved, with long petioles. The cotyledons of Guizotia abyssinica are pubescent as are the two lanceolate primary leaves. The first two of Senecio erucæfolius (fig. 475) are oval, smooth and entire, while the ultimate leaves vary from pinnatifid and pinnatipartite forms to those that are twice divided. The cotyledons are oval and entire immediately after germination, but they soon become emarginate and ultimately orbicular. The emargination is due to the more rapid growth of the sides as compared with the apex. Those of Leuceria senecioides are rotund, emarginate, cuneate at the base and ciliate when young. The two primary leaves are obovate or cuneate and repandly dentate or shallowly lobed, penninerved and finely pubescent. The cotyledons of Odontospermum spinosum are oblong-orbicular, entire, glabrous, and much larger than the first two leaves which are oblanceolate and coarsely hairy. A striking departure from the above is met with in Senecio cruentus which has oblong-ovate or roundly ovate, subemarginate cotyledons, also auricled at the base, or slightly cordate, with slender petioles. The hypocotyl is very short. This differs widely from all other species of Senecio observed, and is evidently a rare type amongst the Compositæ. The first three leaves are cordate, repandly dentate, and also constitute an exception in the Order. The cotyledons of Moscharia rosea (fig. 486) are oblate, emarginate and truncate at the base greatly resembling those of Cuphea silenoides, a species of Loasa, or a Labiate. The two first leaves are sinuately pinnatifid. The form of the cotyledons is already well marked in the seed, but they widen considerably and change their form after germination.

The second division—including the elongated or large cotyledons—is the largest, and apparently contains the more typical forms occurring in the Order. The species may be grouped into those having linear, narrowly spathulate, broadly spathulate, obovate, ovate and lanceolate cotyledons. There is, however, every intermediate gradation between these types, so that the one merges insensibly into the other. In many cases, however, a large number of the species belonging to the different types constitute groups which are more or less closely allied and belong to the same genus or tribe.

As a fairly representative seedling with linear cotyledons, I may refer to that of Ursinia speciosa with linear, entire, fleshy, glabrous and sessile cotyledons. The first two leaves are opposite and pinnatisect with linear segments; succeeding ones are more or less divided; and the ultimate ones are again like the first. They are auricled at the base from the fifth leaf onward and superficially appear to be stipulate. The cotyledons of U. anthemoides are broader and longer, while the first two leaves are like those of U. speciosa. The allied Coreopsis gigantea (fig. 464) has much longer cotyledons than either of the last two, and they are slender and somewhat undulated. The primary pair of leaves are similar to those of Ursinia speciosa, but the linear segments are longer. The ultimate leaves are bipinnatisect with long, linear, slender segments. The cotyledons of Bidens humilis (fig. 465) are linear and very small. The leaves are opposite, dimorphic and present a very interesting case of evolution. The first pair are pinnatisect with linear segments, and succeeding ones are two or three times pinnately cut or multisect. In a batch of plants about half grown, many of them will produce leaves on the upper part of the stem of a different character from those described. They are ternately pinnatisect, with triangular or ovate segments, generally cuneate at the base, the terminal one largest and simply or doubly incise-serrate.

A number of species belonging to different genera may be grouped together here on account of the resemblance of the seedlings both as regards the cotyledons and the primary leaves. They are mostly annual and the cotyledons are narrowly linear, frequently semiterete, and the first pair of leaves are opposite and similar to the cotyledons, but longer and rather broader especially above the middle. Coreopsis filifolia and C. Douglasii are instances, at least as regards the first pair of leaves. Relhania sessiliflora has the first seven pairs of leaves linear, entire, and gradually longer and broader than the cotyledons. The first three or four pairs of the leaves of Burrielia gracilis are precisely similar to, but larger than, the cotyledons. The same may be said of Bæria chrysostoma. The leaves of Microseris Bigelovii are alternate, and the first six at least are linear and slightly widened above the middle. The primary leaves of Tragopogon crocifolium are also linear and slender and the ultimate ones are never very wide. The cotyledons vary from 7·5–8·5 cm. in length. The two species last mentioned belong to the tribe Cichoriaceæ and therefore have no affinity with those previously mentioned with linear cotyledons and leaves. Tussilago Farfara (fig. 474) has linear cotyledons, but they are small, and possibly do not exceed 5 or 6 mm. in length. The first leaf is spathulate; the second ovate; the third similar or triangular; and the fourth and fifth are cordate, recalling the primary ones of Senecio cruentus, to which it is more closely allied than to any other in the group of species with linear cotyledons. The narrowness of the cotyledons as far as I have observed bears a direct relation to that of the fruit and seed in which they were developed. Lasthenia glabrata has linear cotyledons, and the two first pairs of leaves are similar but larger. The cotyledons of L. obtusifolia Bridgesii show a tendency to be spathulate-linear, and while yet in the seed are spathulate-obovate. The species may be regarded as an intermediate type tending towards those having strictly spathulate cotyledons.

A fairly representative type of the spathulate cotyledons is furnished by Cryptostemma calendulaceum. The first two leaves are spathulate and slightly dentate. Succeeding ones are broader, and from the fourth onward they are lyrate-pinnatifid. Evolution of the leaves is also exhibited by Dahlia variabilis, the first four pairs of which are ovate, and the fifth pair more or less pinnatisect. Tagetes patula (fig. 467) and T. glandulifera have also very typical cotyledons, with the primary leaves opposite, pinnatisect, and their segments extremely unequal in size. A peculiarity of T. patula is that the under side of the cotyledon has a submarginal line of glands similar to those on the leaves. The first pair of leaves of Bidens ferulæfolia are pinnatifid, and the cotyledons linear-spathulate. Those of Heterospermum diversifolium are spathulate while the leaves are opposite, or verticillate in threes, and the first pair linear-spathulate, as is the first one of Haplopappus, all the others being alternate and the cotyledons linear-spathulate. Those of Urospermum are broader and more typical; and the first leaf is oval, entire, and ciliated. The cotyledons of Rhagadiolus stellatus (fig. 487) conform to the type, but the species belongs to the tribe Cichoriaceæ, and has runcinate leaves decurrent upon the petiole; the first one has a broadly-elliptic and short lamina suddenly cuneate at the base and decurrent upon the petiole. Gerbera lanuginosa (fig. 484) forms a rather distinct type with spathulate-oblong cotyledons and slender petioles. The first leaf is rhomboid and angled while the second is cordate, and the ultimate ones lyrate-pinnatifid, or slightly runcinate. The cotyledons of Coreopsis laciniata, C. tinctoria, C. coronata and others have shortly and rather broadly spathulate cotyledons, tapering into long petioles. The leaves of the first pair are spathulate, rather broader than the cotyledons, and those of the second often similar but broader, and C. coronata may have several pairs which are oval or bluntly elliptic and entire. A striking departure from the type, and a rare form amongst the Compositæ is presented by C. Atkinsoniana (fig. 461). The cotyledons are unequal, a character due to the fruit being considerably curved and concave. Immediately after germination they are broadly oval, tapered to the base and sessile, but they gradually become petiolate. Other rather exceptional cases are met with in Layia heterotricha (fig. 466) and L. elegans, the cotyledons of which are spathulate, emarginate, rather retuse and cuneate at the base.

With the exception of Senecio erucæfolius and S. cruentus, and the two rare types above given, all the other species coming under my notice agree pretty closely with one another in the shape of their cotyledons, which may be described as oblong-spathulate, and as a rule suddenly tapered into a rather long petiole. S. vulgaris represents this type pretty fairly. The first leaf is spathulate, obsoletely serrate; the next four are oblong-spathulate, irregularly dentate; and the rest mostly lyrate-pinnatifid. S. squalidus has rather broader leaves, but the first five do not otherwise greatly differ from those of S. vulgaris. Two species are notable for the shortness of their hypocotyl, namely S. viscosus and S. polycephalus. The first four leaves vary between ovate and oblong-oval. The cotyledons of the second species are rather the broader. Those of S. elegans are narrowly spathulate and more like the general type of the extensive group with spathulate cotyledons reminding us of Tagetes. The first four leaves are rotund and more or less angled or obsoletely dentate, while succeeding ones are lyrate-pinnatifid with a rounded sinus. The first twelve leaves of S. neelgherianus are spathulate and merely differ in size and depth of toothing. Possibly the ultimate leaves are also spathulate. An uncommon form is met with in S. speciosus which has spathulate cotyledons, connate at the base. The first leaf is broadly elliptic, while the four succeeding ones are more decidedly elliptic and obsoletely dentate. The ultimate leaves are strap-shaped, pinnatifid and dentate. The cotyledons of S. pulcher are inclined to be elliptic. The first leaf is spathulate; the second and third rotund; the fourth oblong, and the ultimate ones oblong or elliptic, fleshy and unequally dentate. An unusual type occurs in S. tetranthus where the cotyledons are broadly oval or elliptic with long slender petioles, and the first leaf is broadly ovate, slightly dentate and hairy.

I pass on now to the broadly spathulate type. It is difficult to define the exact limits of this group, considering that in rich soil or under otherwise favourable conditions seedlings of many species sometimes attain exceptional vigour, and the cotyledons develop greatly in length or breadth, or both. The species of Centaurea and Carduus, or most of the tribes represented by these genera, have large seeds and embryos, and their cotyledons therefore often attain a large size. The Centaureas are represented by C. Clementei (fig. 482), which has broadly spathulate leafy cotyledons. The first leaf is also spathulate, entire, and trinerved, but is acute at either end. Two or more of the primary leaves of C. ragusina are spathulate and entire, followed by some that are ovate and dentate.

The ultimate ones are lyrate-pinnatifid. The cotyledons of Gaillardia pinnatifida (fig. 468) are oblong-spathulate and very variable in size according to vigour. The first three leaves are similar but larger and petiolate, while the ultimate ones are entire or sublyrate-pinnatifid.

The cotyledons of Carduus giganteus are obovate-oblong or spathulate, petiolate, connate at the base, slightly penninerved, and shallowly emarginate. The first two leaves are lanceolate-elliptic, spiny, hairy and rather smaller than the cotyledons. Silybum Marianum (fig. 481) has very similar cotyledons. The leaves are variously blotched and reticulated with silvery white. The two first ones are oval succeeded by two or three oblong, and all are doubly spiny-toothed at the margin. Cnicus syriacus has leaves somewhat similarly blotched to those of the last named, and the first six are elliptic or oblong-elliptic and spiny-toothed. The cotyledons are broad and slightly emarginate. Cnicus diacanthus (fig. 480) has also broadly spathulate cotyledons, and the first three leaves are oblanceolate and slightly spiny-toothed. The ultimate ones are strongly spiny, and all have the midribs and principal nerves of a silvery white. The cotyledons of Tyrimnus leucographus are oblong and subfleshy. The leaves are irregularly blotched with silvery white as in the case of Silybum Marianum; the first two are oval and minutely spiny-toothed, succeeded by three others which are oblong or oblong-obovate, lobed and spiny. The cotyledons of Zollikoferia are spathulate-obovate, trinerved and slightly emarginate, and the first two leaves are oval and finely repand-dentate.

There is no exact line of demarcation between broadly spathulate cotyledons and those which may more rightly be termed obovate, as the one type gradually merges into the other. The obovate type is represented by Venidium calendulaceum. The cotyledons have also a well-marked emargination and the first two leaves are lanceolate, trinerved, hairy and entire. Gundelia Tournefortii may also be placed here. Its cotyledons have a curious longitudinal furrow, which may or may not be median, and appears to be due to folding while yet in the seed. The seedling of Berkheya purpurea (fig. 479) strongly resembles that of a Carduus or Cnicus, but the cotyledons are shorter and less tapered at the base. The first two leaves are elliptical and spiny-serrate, while the ultimate ones are ligulate or oblanceolate, undulately lobed and spiny. Sonchus squarrosus and S. arvensis belonging to the tribe Cichoriaceæ have obovate emarginate cotyledons. The first leaf of S. squarrosus is roundly ovate and dentate. Helianthus cucumerifolius (fig. 459), also belonging to a very different affinity from Carduus, or Venidium, has obovate, entire or slightly emarginate, shortly petiolate cotyledons. The first pair of leaves are oblong and entire; the second pair lanceolate; and from thence they pass through ovate to cordate or triangular forms all more or less distinctly dentate-serrate.

The ovate type of cotyledon is well represented by Mutisia ilicifolia (fig. 483). Here the cotyledons are ovate, acute, fleshy, both turned upon one side and recurved. The first three leaves are ovate or cordate, and repandly spiny-toothed. The cotyledons of M. copiapina are oblong-ovate, acute, of great size, spreading, with numerous, faint, incurved nerves. The first three leaves are oblong, sessile, and repandly spiny-toothed. In Ainsliæa fragrans the cotyledons are much smaller, ovate, obtuse and trinerved beneath. The first leaf is roundly cordate and pubescent. Gamolepis annua has broadly oblong-ovate, emarginate cotyledons, and the first two leaves at least are deeply pinnatifid with linear or narrowly lanceolate segments. G. Tagetes differs considerably from the last named in having oval cotyledons with a cuneate base. The first leaf is deeply trifid and all succeeding ones are pinnatisect with linear segments. Both species are annuals.

The only species having truly lanceolate cotyledons coming under my notice is Gonospermum fruticosum. The cotyledons are linear-lanceolate, trinerved, sessile, subacute, and 6·5 to 7·5 cm. long. The first leaf is narrowly ovate, and serrate. The three following are pinnatisect with three segments each, of which the lateral ones are very small, and the terminal ones like the first leaf, except that they are more cuneate at the base.

Haplopappus pectinatus, *Auct.*

Primary root very long, gradually tapering, slightly branched.

Hypocotyl tapering indistinguishably into the root, 2·5–3 cm. long.

Cotyledons linear-spathulate, obtuse, entire, slightly connate at the base, glabrous, 1·4–1·5 cm. long, 2–2·5 mm. wide.

Stem herbaceous, erect, terete, thinly glandular; 1st internode 2·5 mm. long; 2nd shorter.

Leaves simple, cauline, alternate, exstipulate, thinly glandular, tapering into the petiole which is slightly channelled above, and semiamplexicaul at the base; principal veins traversing the leaf longitudinally.

No. 1. Narrowly spathulate, entire, obtuse, mucronate.

Nos. 2 and 3. Narrowly spathulate, tapering into a slender petiole, with one or two teeth on each side near the apex.

No. 4. Spathulate, deeply incise-dentate with distant teeth.

Nos. 5–9. Deeply pinnatifid with linear-oblong, horizontally spreading segments.

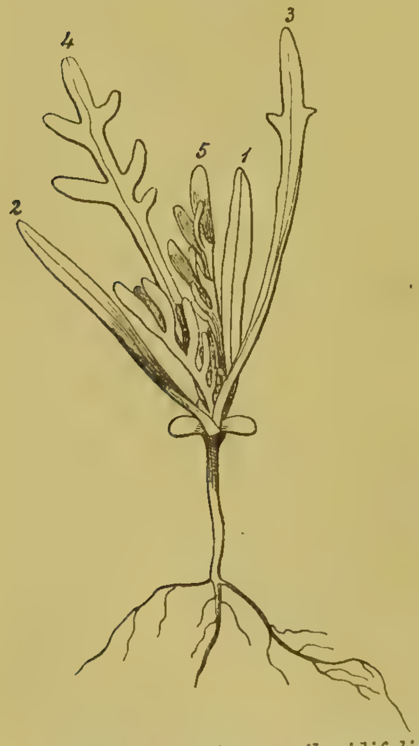

Fig. 457.—*Brachycome iberidifolia.* Nat. size.

Brachycome iberidifolia, *Benth.* (fig. 457).

Primary root tapering downwards, with lateral fibres, annual.

Hypocotyl erect, terete, very short, tapering indistinguishably into the root.

Cotyledons short, oblong, obtuse, entire, fleshy, convex on both surfaces or nearly flat above, tapering to the base, then connate and forming a cup around the plumule, with an indistinctly discernible midrib, glabrous, light green or stained with red beneath, 4–4·5 mm. long, 1·75–2 mm. wide.

Stem herbaceous, annual, erect; primary internodes short or not developed.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, or narrowed to the base and not truly petiolate, alternately but indistinctly penninerved, fleshy or subsucculent, glabrous, light green above, paler beneath, petiole or petiole-like base, channelled above, obtusely subcarinate beneath, dilated at the very base and subamplexicaul.

Nos. 1 and 2. Linear, obtuse, entire.

No. 3. Linear, obtuse, with one to two obtuse teeth or segments near the apex, gradually tapering with a long petiole-like base.

No. 4. Pinnatifid with two to three alternate, oblong, obtuse segments on each side.

No 5. Pinnatisect with linear-oblong, obtuse, entire segments.

No. 6. Pinnatisect with narrow, linear, obtuse, entire segments.

Bellis perennis, *L.* (fig. 458).

Primary root tapering downwards, flexuose with numerous lateral, flexuose, simple or branching fibrous rootlets.

Hypocotyl erect, very short, mostly subterranean and passing insensibly into the root.

Cotyledons rotund, entire, or more frequently minutely and shallowly emarginate, petiolate, light green above, paler beneath, with an indiscernible venation, glabrous; lamina horizontal, 3·5–3·75 mm. long, 3·5–4 mm. wide; petiole broad, flattened above, convex on the back, dilated and connate at the base, pale green or almost colourless, ascending, 1·5–2 mm. long.

Stem creeping and rhizomatous, seldom ascending, but undeveloped in the young state, ultimately branching; primary internodes undeveloped.

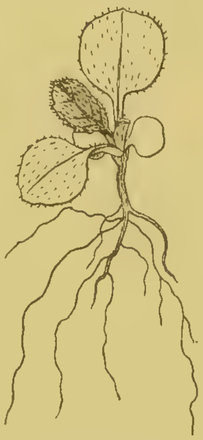
Fig. 458.
Bellis perennis.
Nat. size.

Leaves simple, radical, alternate, exstipulate, petiolate, alternately incurvinerved and obscurely reticulate, hairy on both surfaces, bright or deep green above, paler beneath; petioles obtusely keeled or rounded on the back, channelled above, dilated at the base.

Nos. 1 and 2. Rotund, nearly or quite entire.

No. 3. Rotund, obsoletely glandular-dentate, or denticulate.

Charieis heterophylla, *Cass.*

Primary root tapering downwards, with numerous lateral fibres.

Hypocotyl obconical, short, 6–7 mm. long, light green or colourless.

Cotyledons obovate-oblong, obtuse, entire, fleshy, sessile, glabrous, green, one-nerved, slightly unequal.

Stem erect, terete, herbaceous, hirsute; 1st internode 7–8 mm. long; 2nd about the same; 3rd shorter.

First leaves simple, entire, cauline, opposite, decussate; later ones alternate, oblong or spathulate, tapering at the base to a broadish petiole, hirsute, green, very indistinctly pinnatinerved; some of the later leaves appear sessile and slightly toothed.

Relhania sessiliflora, *Thunb.*

Hypocotyl erect, terete, glabrous, 2–9 mm. above the soil.

Cotyledons linear, acute, sessile, subfiliform or terete, glabrous, green or stained with purplish-brown, 1·2–1·5 cm. long.

Stem herbaceous, annual, erect, terete, glandular-hairy; 1st internode 4–7 mm. long; 2nd similar.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, sessile and slightly connate at the base, glandular-hairy, with the midrib slightly furrowed above and prominent beneath.

First to seventh pairs linear, acute, gradually longer, and broader than the cotyledons.

Odontospermum spinosum, *Auct.*

Achene hairy; pappus simple.

Seed obovoid, about 2 mm. long; testa smooth, thin, dark brown; hilum inconspicuous.

Embryo straight, filling the entire cavity of the seed, greyish or colourless; cotyledons thick, fleshy, oblong, obtuse, sessile, entire; radicle inferior, terete, obtuse, very much shorter and rather narrower than the cotyledons.

Seedling.

Hypocotyl erect, terete, short, about 7·5–10 mm. long, light green or colourless, glabrous.

Cotyledons almost orbicular, entire, obtuse, glabrous, shortly petiolate, dark green; venation indistinct.

Stem with the first internodes undeveloped, the leaves appearing immediately above the cotyledons.

Primary leaves simple, entire, narrow, obovate or obtusely oblanceolate, tapering at the base but scarcely petiolate, exstipulate, ciliate and covered all over with bristly hairs; venation represented by a prominent midrib.

Rudbeckia serotina, *Sweet.*

Hypocotyl short, hardly appearing above the surface of the soil.

Cotyledons subrotund, obtuse, minutely emarginate, fleshy, glabrous, green, with no apparent venation, very shortly petiolate.

Stem with primary internodes undeveloped.

First leaves simple, radical, entire or slightly serrate, alternate, petiolate, exstipulate, broadly lanceolate, subacute, hirsute, green, trinerved; petiole very long, covered with stiff bristles, deeply channelled on the upper side.

Helianthus annuus, *L.*

Achene obovoid, much compressed, but thickest near the apex, tipped with the persistent base of the flower, glabrous, brown, striped or mottled with grey; outer coat thin, membranous; inner thickened or subwoody at the lateral edges.

Seed obovate, much flattened but obtusely tetragonal, conforming in outline to the achene, but shrunk when dry; testa thin, membranous, white, closely applied to the seed.

Endosperm absent.

Embryo large, straight, conforming in outline to the seed; cotyledons obovate, obtuse, entire, plano-convex, closely applied to each other face to face, colourless; radicle short, turbinate, obtuse.

Helianthus cucumerifolius, *A. Gray* (fig. 459).

Achene differs from that of H. annuus in being much smaller, oblong-obovate, and obtusely tetragonal with the lateral angles smaller and more obtuse, while the apex is more truncate, and sometimes depressed, causing an emargination of the cotyledons.

Primary root slender, colourless, with a few fibrous lateral rootlets.

Hypocotyl herbaceous, terete, glabrous, about 3 cm. long, 1 mm. thick, brownish-green.

Cotyledons subsessile and semiamplexicaul, 1·2–1·5 cm. long, over 5 mm. wide, obovate-spathulate, rounded at the apex, entire or slightly emarginate, obscurely nerved, glabrous, thin, light green.

Stem with the first internode 5 mm. long, terete, succulent, green, covered with silky hairs.

Leaves cauline, opposite, exstipulate, simple, connate and clasping the bases of their petioles.

First pair entire, oblong, obtuse, obscurely trinerved, coarsely pubescent on both sides, tapering into the channelled petiole, 2·5 cm. long, 5–7 mm. wide; petiole 3–5 mm. long.

Second pair lanceolate-ovate, obtuse or subacute, trinerved, serrulate with gland-tipped serratures, coarsely pubescent above, almost villous beneath, with short petioles.

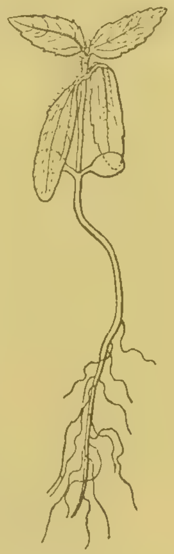

FIG. 459. *Helianthus cucumerifolius.* Half nat. size.

Ultimate leaves cordate-acuminate or more often triangular, acute or subacuminate, more or less cordate at the base, tri-nerved in the lower half and alternately penninerved upwards, coarsely and irregularly toothed, scabrous on both surfaces.

Guizotia abyssinica, *Cass.*

Hypocotyl erect, terete, pubescent, 8–15 mm. long, light green or colourless.

Cotyledons ovate-orbicular, obtuse, emarginate, petiolate, pubescent, dark green, pinnatinerved, like the leaves.

Stem erect, terete, herbaceous ; 1st internode 2–3 mm. long.

First leaves simple, entire, cauline, opposite, lanceolate, obtuse, shortly petiolate, exstipulate, pubescent, light green, pinnatinerved.

Heterospermum diversifolium, *H. B. K.*

Primary root soon giving off very strong lateral rootlets which keep the primary one in check, annual.

Hypocotyl erect, terete, glabrous, 5–8 mm. long.

Cotyledons spathulate, obtuse, entire, sessile, tapering to the base and slightly connate, glabrous, with a distinct midrib, 1–1·3 cm. long, 2–2·75 mm. wide above the middle.

Stem annual, herbaceous, erect, terete, somewhat striate, with rows of hairs from the edges of the leafstalks downwards ; 1st internode 3–4 mm. long ; 2nd 7–11 mm.

Leaves simple, cauline, opposite, decussate or verticillate in threes, exstipulate, somewhat hairy on both surfaces, with strong, sharply-ascending nerves ; petioles channelled above, slightly connate at the base.

First pair linear-spathulate, obtuse, entire, or sometimes subcuneate, rather deeply trifid.

Second pair ovate, pinnatifid, with about five segments.

Third to sixth pairs ovate-elliptic or subrhomboidal, cuneate at the base and shallowly serrate, not pinnatifid.

Coreopsis Atkinsoniana, *Dougl.* (fig. 460).

Achene oval in outline, convex both in a longitudinal and transverse direction dorsally, but involute at the margins and concave ventrally, with a small, somewhat elevated scar at either end, smooth on the back and minutely dotted or reticulated, or distinctly echinulate, black.

Seed obovate, curved longitudinally and compressed dorso-ventrally, conforming to the interior of the fruit ; testa pale or whitish, thin, membranous; hilum and micropyle inferior, contiguous; chalaza apical, superior.

Endosperm absent.

Embryo large, straight or slightly curved longitudinally, conforming to the interior of the seed, colourless; cotyledons rotund-obovate, entire, plano-convex and closely applied face to face, lying in the broader plane of the seed with their back towards the axis of the receptacle or inflorescence, much longer than the very short, turbinate, obtuse radicle at the base of the seed.

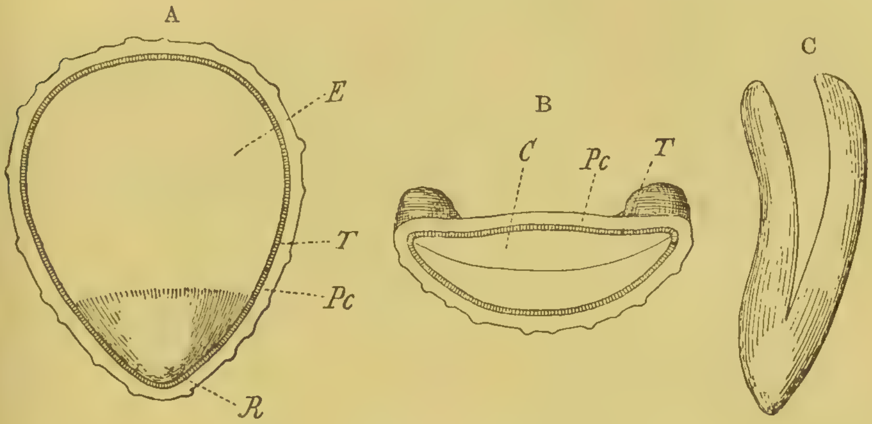

Fig. 460.—*Coreopsis Atkinsoniana*, × 20. A, longitudinal section of achene: *E*, embryo; *T*, testa; *Pc*, pericarp; *R*, radicle. B, transverse section of achene: *C*, cotyledon; *Pc*, pericarp; *T*, testa. C, embryo, showing edges of cotyledons and their relative length to the radicle.

Germination (fig. 461).

The fruit splits vertically along each side, that is right and left corresponding with the position of the cotyledons in the broader plane of the seed and fruit.

The radicle emerges at its base and fixes itself in the ground while the cotyledons increase in size and escape from the fruit. The cotyledons are tinged with purple.

When the fruit has been insufficiently covered, it is often carried up by the germinating embryo.

The figure shows the seedling as it appears three days after germination. The cotyledons are broadly oval, obtuse, entire, narrowed at the base into a short

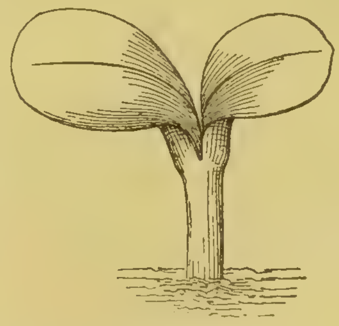

Fig. 461.
Coreopsis Atkinsoniana, × 6.

petiole, glabrous, pale green, more or less stained with purple, somewhat unequal in size owing to their position in the curved seed and fruit. In twelve out of fifteen seedlings the cotyledons were markedly unequal; in the other three only slightly.

Coreopsis auriculata, *L.* (fig. 462).

Achene obovate, winged, wings nearly entire or oftener more or less cut into shreds or short filaments, convex on the dorsal aspect and somewhat curved, subconcave when dry and curved longitudinally on the ventral aspect, with a callosity at its base and a large one at the apex, or two more or less combined, smooth on the dorsal aspect, minutely tuberculated on the ventral, black.

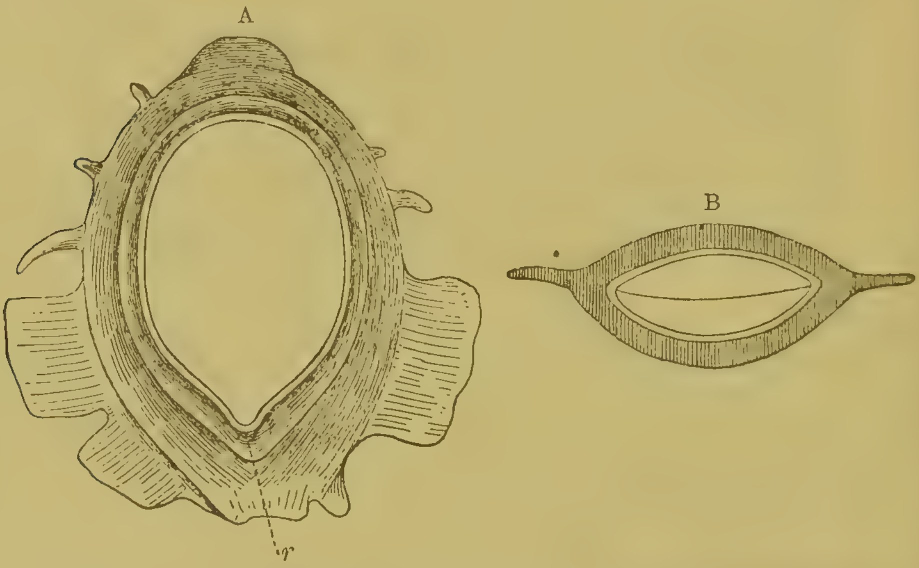

FIG. 462.—*Coreopsis auriculata.* A, longitudinal section of achene, × 14: *r*, radicle. B, transverse section of achene, × 14.

Seed conforming in outline to the cavity of the achene, rounded at the end, suddenly tapered to an obtuse point, much compressed dorso-ventrally, surrounded by a dark line on the middle of both dorsal and ventral aspect, slightly curved longitudinally like the achene; hilum basal; chalaza apical; testa thin, pale, membranous.

Endosperm absent.

Embryo large, slightly curved in accordance with the achene and seed, colourless; cotyledons obovate or broadly oval, rounded at the apex, entire, suddenly narrowed to the radicle; radicle very short, obtuse.

Coreopsis filifolia, *Hook.* (fig. 463).

Achene linear or subcylindrical, narrow, biconvex, smooth on the ventral aspect, obtusely muricate on the dorsal, curved outwards in the middle or away from the central axis, shortly two-horned at the apex, with a slightly oblique, somewhat thickened basal scar.

Seed cylindrical, conforming to the shape of the achene, curved; testa thin, membranous, white; raphe and chalaza inconspicuous; micropyle and hilum basal.

Endosperm absent.

Embryo slightly curved, filling the seed, pale yellowish-white; cotyledons linear, obtuse, entire, plano-convex; radicle turbinate, obtuse, about one-fourth the length of cotyledons.

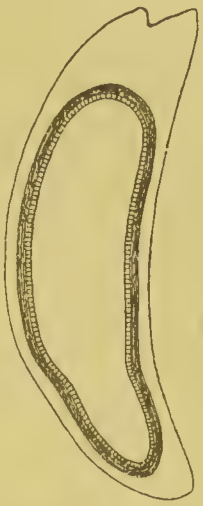

Fig. 463.—*Coreopsis filifolia.* Longitudinal section of achene, × 14.

Coreopsis gigantea, *Benth.* (fig. 464).

Primary root slender, tapering downwards.

Hypocotyl erect or ascending from a thickened base, terete, glabrous, shining, red at the base and pale green above, and more slender, 2·5–4·5 cm. long.

Cotyledons linear, obtuse, subundulate, subsucculent, flattened and slightly channelled along the midrib, horizontal, 2·5–3 cm. long.

Leaves simple, pinnatisect, cauline, opposite, exstipulate, petiolate, subsucculent, glabrous; petioles subterete, channelled above.

First pair pinnatisect with two pairs of lateral, and one terminal, linear, obtuse segment. The ultimate leaves are triangular in outline, two to three times pinnatisect; segments all slender, filiform, slightly channelled above.

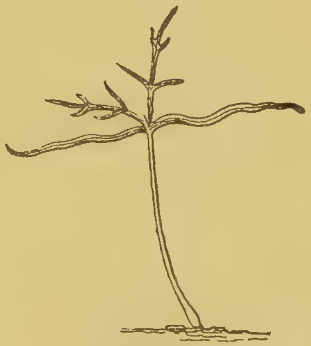

Fig. 464.
Coreopsis gigantea.
Half nat. size.

Coreopsis laciniata, *Auct.*

Primary root short, suddenly tapering, branched, annual.

Hypocotyl very short, tapering indistinguishably into the root, 5–8 mm. long.

Cotyledons shortly spathulate, tapered into a long petiole, entire with a black gland at the apex, an indistinct midrib and a marginal nerve best seen on the under surface, glabrous; lamina 4–5 mm. long, 2·5–3 mm. wide; petiole flattened above, connate at the base round the stem, 5–5·5 mm. long.

Stem herbaceous, erect, terete, glabrous; 1st internode 4–5 mm. long; 2nd 1·6–1·8 cm.

Leaves nearly or quite glabrous, with indistinctly reticulate venation; petiole connate at the base, channelled above, with a few hairs on the margin at the base.

First pair spathulate, obtuse, entire, with long petioles.

Second pair spathulate, or oblong-elliptic, obtuse, entire, with long petioles.

Third pair pinnatifid; with about two pairs of lateral lobes, linear, obtuse, entire; terminal lobe lanceolate, obtuse, entire, tapered to the base, much longer than the lateral ones.

COMPARATIVE SIZE AND NUMBER OF FRUITS IN COREOPSIS.

Coreopsis auriculata, L.—Receptacle considerably elevated like a torus, 3·25–5 mm. in diameter, bearing seventy to one hundred and ten fruits or achenes, of which only five to fifteen ripened in the specimens examined. Achenes 3·25–3·5 mm. long, 2·5–3·5 mm. wide, ·75–1 mm. thick, slightly curved longitudinally and concave on the ventral face.

C. filifolia, Hook.—Receptacle flat or slightly convex, 3–4·5 mm. in diameter, bearing sixty-five to seventy-six achenes, of which four to fifteen ripened in the specimens examined. Achenes narrow, somewhat curved longitudinally, 3·75–4·25 mm. long, 1·25 mm. wide, 1 mm. thick.

C. lanceolata, L.—Receptacle convex, 4–5 mm. in diameter, bearing seventy to eighty-five achenes. Achenes flattened, or convex on the back, ciliated at the margins, terminating in two teeth.

C. latifolia, Michx.—Receptacle flat, 3–4·25 mm. in diameter, bearing eighteen to thirty achenes, of which very few (one to two or more) ripened in specimens examined. Achenes oblong, compressed, two-edged, with a ridge along each face, ending in two very short blunt teeth, slightly curved longitudinally, 7–8 mm. long, 2·25–2·75 mm. wide, 1–1·3 mm. thick.

C. tinctoria, Nutt.—Receptacle 3·5–5 mm. in diameter, slightly convex, bearing one hundred to two hundred achenes, of which forty to one hundred and forty-five ripened in specimens examined. Achenes longitudinally curved, rounded and echinulate on the back, flattened and slightly convex on the face, minutely reticulate, 1·5–2 mm. long, ·75–1 mm. wide, ·25–·33 mm. thick.

C. Atkinsoniana, Dougl.—Receptacle elevated, 2·5–6·75 mm. in diameter, bearing eighty to one hundred and thirty-six achenes, of which fifty to ninety-four ripened in specimens examined. Achene almost semiglobose, concave on the ventral aspect, echinulate dorsally, 2–2·25 mm. long, 1·5–1·75 mm. wide, ·5–1 mm. thick.

C. bicolor, Rchb.—Receptacle convex, 3·5–6 mm. in diameter, bearing one hundred and eighty to two hundred and sixteen achenes, of which one hundred to one hundred and sixty ripened in the specimens examined. Achene 2–2·33 mm. long, ·75–1 mm. wide, ·25 mm. thick, oblong, slightly curved longitudinally, and generally tapering slightly to the ends, with a small white basal callosity, minutely echinulate on both surfaces.

Dahlia variabilis, *Desf.*

Achene narrowly obovate or spathulate, notched at the apex with a little tooth in the sinus, giving the whole a tridentate appearance, compressed, obtusely ancipitous, disarticulated at the base transversely, with a shallow oval areola, black.

Seed conforming to the interior of the fruit, but readily separable from it; testa thin, pale or colourless, longitudinally striate.

Endosperm absent.

Embryo straight, occupying and conforming to the interior of the seed, fleshy, colourless; cotyledons spathulate, obtuse, entire, tapering gradually to the short radicle, plano-convex and applied to each other, face to face; radicle inferior, obtusely pointed, close to the hilum.

Seedling.

Primary root long, tapering, with lateral rootlets, ultimately supplanted by more or less fusiform tubers springing from below the cotyledons, and in close proximity to them.

Hypocotyl subterranean or indistinguishable from the root.

Cotyledons spathulate-linear.

Stem erect, terete, herbaceous, hairy, ultimately glabrous or thinly hairy, greenish-purple, striated with darker lines; 1st internode 14 mm. long; 2nd 4 mm.; 3rd 2·5 mm.; 4th 5 mm.

Leaves opposite, pinnatisect, glabrous above except on the nerves, deep green, ciliate at the margins, paler beneath and hairy; petioles channelled on the upper side, and more or less winged.

First pair ovate, obsoletely serrate, cuneate at the base.

Second pair ovate, rather coarsely dentate-serrate.

Third pair similar but more rounded at the base.

Fourth pair unequal; one leaf ovate, serrate; the other tripartite with ovate, serrate segments; the lateral ones much the smallest.

Ultimate leaves pinnatisect, with three to five or more segments; segments ovate, acuminate, coarsely serrate, opposite, the lower pair generally stalked with or without two small segments on their basal posterior side. Upper leaves tripartite; uppermost undivided and shortly stalked or sessile or reduced to bracts.

Bidens humilis, *H. B. K.*

Achene linear, very narrow, obtusely tetragonal with shallow ridges and furrows between, glabrous, black; two of the angles predominate and are produced into two horns surmounting the fruit.

Seed linear, slightly broader than thick, conforming to the interior of the achene, only falling short of the length of the cavity; testa thin, membranous, white or nearly so; micropyle and hilum contiguous, basal, inferior; chalaza superior.

Endosperm absent.

Embryo comparatively large, filling the entire seed, straight, colourless; cotyledons linear, obtuse, entire, plano-convex, closely applied face to face, lying in the broader plane of the seed with their backs to the axis of the receptacle, narrowed somewhat towards the base; radicle terete, obtuse, slightly shorter than the cotyledons, pointing to the base of the fruit but some distance above it.

Receptacle somewhat concave, 3–3·5 mm. in diameter, bearing forty to sixty achenes, of which thirty-five to fifty ripened in the specimens examined. Achenes linear, slender, straight, 5–7 mm. long, exclusive of the awns or teeth, ·75 mm. wide, ·5 mm. thick, four-ribbed longitudinally.

Seedling (fig. 465).

Primary root long, flexuose, with numerous lateral rootlets, annual.

Hypocotyl erect, terete, glabrous, reddish, about 8 mm. long.

Cotyledons linear, obtuse, subfleshy, flattened above with a sunk midrib, convex beneath, broadest above the middle, amplexicaul and connate at the base, about 1 cm. long, 1–1·25 mm. wide.

Stem herbaceous, annual, erect, terete, densely covered with hyaline, coarse, jointed hairs, and densely pubescent especially when young; 1st internode 5·5 mm. long; 2nd 9 mm.; 3rd 1·1 cm.; 4th 1·8 cm.; 5th 4 cm.; 6th 2·5 cm.

Leaves simple, bi- to tri-pinnatisect, or by reversion pinnatisect, opposite, more or less hairy on both surfaces with a line of short incurved hairs along the sunk median nerve of every segment, deep green above, pale beneath; petioles hairy, channelled above, convex on the back, dilated and amplexicaul at the base.

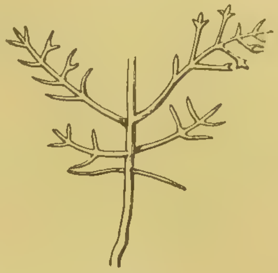

FIG. 465.—*Bidens humilis.* Half nat. size.

First pair trifid or pinnatifid with two linear obtuse segments on each side.

Second pair with a short broadly triangular limb, pinnatisect with the basal segments largest and trifid.

Third pair triangular, bipinnatisect, with oblanceolate-linear segments.

Fourth pair triangular-ovate, bipinnatisect with the secondary segments slightly cut.

Fifth pair triangular-ovate, bipinnatisect.

Ultimate leaves triangular-ovate, bi- to tri-pinnatisect with the ultimate segments oblanceolate-linear or oblong, entire or slightly cut, acute. By reversion many of the stems and branches produce, towards the top, leaves that are merely ternately pinnatisect with triangular or ovate pinnatifid or merely incise-dentate segments, and broad slightly toothed lobes.

Nearer the top of these branches the leaves are ternately pinnatisect with ovate, acute incise-serrate segments.

B. leucantha, *Willd.*—Receptacle slightly concave in the early stages, ultimately flat or somewhat convex, 4·25–7 mm. in diameter, bearing fifty to seventy-one achenes of which thirty-seven to sixty-four ripened in the specimens examined. Achenes linear, slender, obtusely tetragonal, with a few ascending bristles towards the apex, and terminated by two to four awns, of which two are nearly always the strongest and all furnished with reflexed bristles, 6·5–13·5 mm. long, ·75–1·25 mm. wide, ·75–1 mm. thick.

Bidens ferulæfolia, *DC.*

Hypocotyl as in B. humilis, but 2–3·5 cm. long, and light green or colourless with occasionally a faint reddish tinge.

Cotyledons linear-lanceolate, acute, entire, tapering to the base, but not petiolate, fleshy, glabrous, light green, one-nerved.

Stem herbaceous, erect, terete, finely pubescent; 1st internode about 2–4 mm. long.

First leaves cauline, petiolate, pinnatifid, lobes 3–5 mm. long, the end one considerably the largest, acute, light green, pinnatinerved with a lateral nerve running up each lobe, surface with a few hairs. The first pair as in many other Compositæ are opposite.

Madia elegans, *Don.*

Hypocotyl erect, terete, glabrous, 5-6 cm. long, light green or colourless.

Cotyledons broadly spathulate, emarginate, obtuse, sessile, connate at the base, fleshy, glabrous, dark green, one-nerved, the nerve only apparent at the base of the lamina.

Stem ascending, herbaceous, pubescent; 1st internode about 2 mm. long.

First leaves simple, entire, cauline, opposite, decussate, linear, subacute, ciliate, thickly covered with hairs, with those on the under side much smaller, light green, distinctly one-nerved.

Layia platyglossa, *A. Gray.*

Achene obovate or spathulate, ribbed and covered with numerous hairs; pappus short, coronate.

Seed conforming in shape to the achene, exalbuminous; testa membranous, thin; hilum inconspicuous.

Embryo straight, filling the interior of the seed, colourless; cotyledons spathulate, obtuse, emarginate (on account of a depression of the pericarp beneath the style), sessile; radicle terete, obtuse, not quite so long as the cotyledons.

Layia heterotricha, *Hook. et Arn.* (fig. 466).

Hypocotyl erect, terete, glabrous, 1·2–1·5 cm. long, light green or colourless.

Cotyledons spathulate, obtuse, emarginate, tapering to a long narrow base but hardly petiolate, fleshy, light green, indistinctly one-nerved, glabrous.

Stem with the primary internodes but slightly developed.

First leaves linear-spathulate; the first pair are opposite, acute, denticulate, tapering to the base but hardly petiolate, hairy, with a distinct midrib.

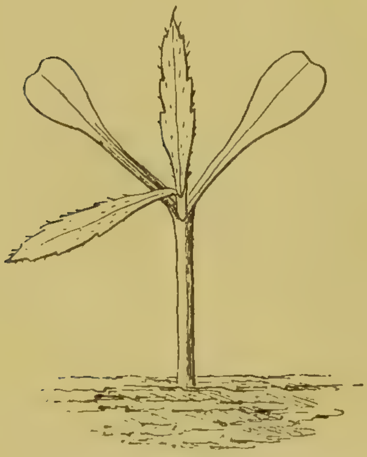

Fig. 466.—*Layia heterotricha.* Nat. size.

The seedling of **Layia elegans**, *Torr. et Gray*, closely resembles the above.

Burrielia gracilis, *DC.*

Primary root slender, fibrous, annual.

Hypocotyl terete, glabrous, 8–12 mm. long.

Cotyledons linear, obtuse, entire, connate at the base and sheathing the stem, glabrous, 1–1·6 cm. long.

Stem herbaceous, annual, erect or procumbent, terete, glabrous or nearly so at the base, and covered with an adpressed pubescence upwards; 1st internode 1–2·7 cm. long.

Leaves simple, entire, cauline, opposite, sessile and connate at the base, very thinly pubescent, semiterete, channelled on the upper side.

First to third or fourth pair precisely similar to the cotyledons, but larger.

Bæria chrysostoma, *Fisch. et Mey.*

Primary root annual, long, tapering gradually and giving off only a few slender rootlets.

Hypocotyl short, terete, glabrous, tapering indistinguishably into the root.

Cotyledons linear, semiterete, slightly flattened above, obtuse or subacute, connate at the base and sheathing the stem for 3 mm., very sparsely pilose, 4–4·5 cm. long, about ·5 mm. wide, recurved at the tip.

Stem herbaceous, erect, terete, glabrous or thinly pilose; 1st internode 1·4–1·7 cm. long; 2nd 1–1·2 cm.

Leaves simple, cauline, opposite, sessile and sheathing at the base, pilose and ciliate at the margin, subsequently more or less glabrescent.

First pair linear, obtuse, or subacute, semiterete, slightly flattened above and curved at the tip like the cotyledons, which they resemble in general appearance.

Second pair broader, linear, obtuse, channelled above, slightly carinate beneath, coarsely and thinly ciliate at the margin, recurved at the tips.

Third pair similar, but broader and recurved at the tips.

Lasthenia glabrata, *Lindl.*

Primary root long and gradually tapering downwards, but slightly branched, annual.

Hypocotyl short, or tapering indistinguishably into the root.

Cotyledons linear, connate at the base, sheathing the stem, flattened above, 2–2·5 cm. long, 1 mm. wide.

Stem herbaceous, annual, erect, terete, glabrous, green and shining; 1st internode 2–2·5 cm. long; 2nd 1·5–1·8 cm.

Leaves as in last species, connate and sheathing at the base, bright green and glabrous, entire.

First pair linear, obtuse, entire, flattened above, slightly broader above the middle, resembling the cotyledons.

Second pair linear, obtuse, flattened above, entire.

Third pair much broader, linear, obtuse, slightly channelled above, entire.

Lasthenia obtusifolia, *Cass., var.* Bridgesii.

Achene obovate-oblong, suddenly narrowed to the base, compressed, slightly keeled on one side, glabrous, 3–3·5 mm. long by 1·25–1·5 mm. wide about or above the middle.

Seed conforming to the shape of the achene.

Embryo conforming to the shape of the seed; cotyledons spathulate-obovate, blunt or slightly emarginate at the apex; radicle conical, nearly as long as the cotyledons. The cotyledons after germination are linear or spathulate-linear, a shape attained by elongation after germination.

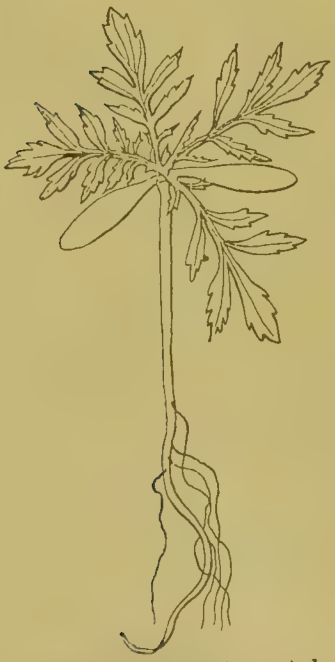

Fig. 467.—*Tagetes patula.* Nat. size.

Tagetes patula, *L.* (fig. 467).

Primary root tapering, flexuose colourless, with many fleshy, colourless, flexuose, fibrous rootlets, annual.

Hypocotyl erect, terete, deep dull purple, closely striate with scabrid lines of papillæ-like hairs, 1·5–2 cm. long.

Cotyledons narrowly spathulate, subfleshy, pale green above, paler beneath, with a prominent midrib and a submarginal row of brownish glands; petiole slightly furrowed above, scabrous beneath, 6 mm. long; limb oblong-obtuse, glabrous, 1·3 cm. long, 4 mm. wide.

Stem herbaceous, annual, terete, glabrous, dull purple; early internodes very short.

Leaves simple, pinnatisect, cauline, opposite, sessile, glabrous, with a submarginal line of brownish glands on the lobes or segments.

First and second pairs much alike; basal segments very small, spathulate, acutely tri-dentate or -fid; middle segments lanceolate, acute, serrulate above the middle; terminal segment lanceolate-elliptic, acute, serrate from the middle upwards; lateral segments alternate; rachis and midrib of segments channelled.

Tagetes glandulifera, *Schrank.*

Primary root very similar to that of T. patula.

Hypocotyl minutely scabrid, pale purple, 2·1 cm. long, 1 mm. thick.

Cotyledons very similar to those of T. patula, tapering into a short petiole, connate at the base, 1·6 cm. long, 3·5 mm. wide.

Stem angled and furrowed; 1st internode 4 mm. long.

Leaves very similar to those of the last species, pinnatisect with mostly alternate segments, and with submarginal, clear, translucent glands.

First pair pinnatisect, tapering much to the base with very unequal segments; basal ones small, slender, spathulate, tridentate, with the teeth often tipped with a bristle; upper segments lanceolate, subserrate; terminal segment lanceolate-elliptic, serrate above the middle.

Second pair similar, except that the terminal segment is very much the largest and oblong, acute, serrate.

Gaillardia pinnatifida, *Torr.* (fig. 468).

Primary root tapering, rather stout, colourless, giving off a few lateral rootlets, annual.

Hypocotyl 2–3 mm. above ground, 1–1·5 mm. thick, fleshy, red, frequently surrounded by the husk of the achene.

Cotyledons oblong-spathulate, sessile, rather fleshy, obtuse, glabrous, variable in length according to vigour of specimen, 6–13 mm. long, 4–5·5 mm. wide.

Leaves simple, radical and cauline, alternate, coarsely hairy on both surfaces; petioles channelled above, convex beneath or somewhat ridged, pubescent.

No. 1. Spathulate, obtuse, or sometimes narrowly elliptic, entire.

No. 2. Oblong, obtuse, entire.

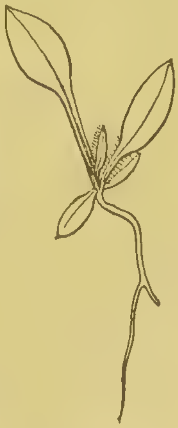

Fig. 468.
Gaillardia pinnatifida.
Half nat. size.

Ultimate radical leaves entire or sublyrate-pinnatifid, spathulate, obtuse, tapering to the base, alternately penninerved, with the nerves ascending and entering the lobes when present, dull subglaucous-green, more or less hairy on both surfaces; petioles channelled above, shallowly ridged on the back, dilated, sheathing and crimson at the base, subscabrously hairy.

Anacyclus radiatus, *Lois.*

Hypocotyl erect, terete, glabrous, 3–4 cm. long, light green tinged with red.

Cotyledons oblong-spathulate, obtuse, entire, tapering to the base but scarcely petiolate, connate at the base, fleshy, glabrous, light green, indistinctly pinnatinerved.

Stem herbaceous; primary internodes undeveloped.

First leaves pinnatifid, cauline, alternate, with a few hairs, tapering to the base, pinnatinerved; lobes acute, entire or bifid, light green.

Gonospermum fruticosum, *Less.*

Hypocotyl erect, terete, covered with very minute hairs, 3·5–3·75 cm. long, brownish.

Cotyledons very long, linear-lanceolate, subacute, entire, tapering to the base, glabrous, green, trinerved, sessile.

Stem erect, terete, herbaceous, ultimately shrubby; 1st internode 2–3 mm. long; 2nd and 3rd about the same.

First leaf simple, ovate-oblong or almost lanceolate, acute, coarsely serrate, covered with minute hairs, green, pinnatinerved; leaves after the first one alternate, pinnatisect; terminal segment similar to the first leaf; lateral segments small, serrate, oblong, acute; petioles short, thick, deeply channelled on the upper face.

Lonas inodora, *Gaertn.*

Seed narrowly obovoid, subcompressed, readily removable when fresh from the achene to the interior of which it conforms.

Embryo conforming to the seed which it wholly occupies; cotyledons plano-convex, obtuse, entire, closely occupying the interior of the upper and broader end of the seed, and applied face to face; radicle tapering to an obtuse point and occupying the narrow end of the seed, nearly equalling the cotyledons in length but much narrower; plumule minute and scarcely, if at all, discernible.

Seedling (fig. 469).

Primary root tapering downwards, giving off slender lateral rootlets, colourless, flexuose, annual.

Hypocotyl erect, terete, stout, tapering into the radicle, pale green, glabrous, 3·5–5·5 mm. long.

Cotyledons oval, obtuse, entire, sessile, connate at the base and forming a cup round the plumule, glabrous, pale green, succulent and without any discernible venation, 4–5·5 mm. long, 3–3·5 mm. wide at the middle.

Stem herbaceous, erect, terete, glabrous, annual, pale green; 1st internode 7–9 mm. long; 2nd 3–10 mm.

Leaves.—Lower opposite, upper alternate, sessile, with a few alternate, ascending nerves on each side of the midrib, glabrous, subsucculent, light green above, paler beneath.

First pair spathulate, subacute or cuspidate, tapering gradually to the base where they are again slightly dilated and connate and grooved on the upper side, many times longer than the cotyledons, decussating with them, entire, with a distinct midrib but no other discernible venation.

Second pair spathulate-cuneate, trifid with ovate, acute, entire teeth or lobules, or the lateral ones sometimes furnished with one or two teeth on the posterior side, with a lateral nerve proceeding straight into each tooth, tapering gradually to the base where they are again slightly dilated and furnished with a number of slender, subulate or setiform teeth, carinate beneath.

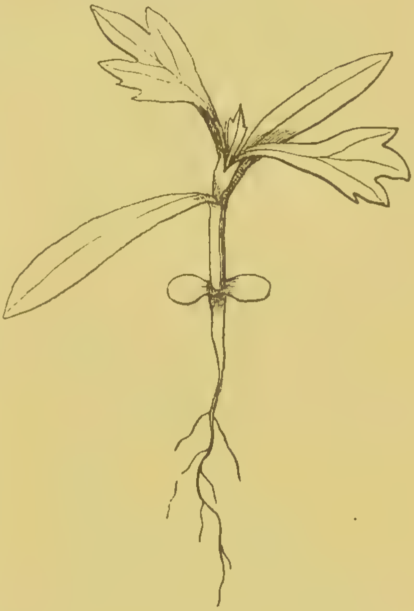

FIG. 469.—*Lonas inodora.* Nat. size.

Third pair cuneate, tapering to the base, deeply trifid, with oblong, slightly toothed segments, each with a strong lateral nerve, carinate on the back, somewhat dilated and connate at the base, for some distance above which they are furnished with slender, subulate, or setiform teeth.

Seventh leaf alternate in specimen examined

Achillea Millefolium, *L.* (fig. 470).

Hypocotyl erect, terete, glabrous, pale green or almost colourless, 6–14 mm. long.

Cotyledons shortly spathulate, tapering to the base and perfoliate, with an indistinct midrib and two lateral nerves arising from the base and passing round the cotyledon immediately within the margin to unite with the midrib near the apex, glabrous, light green above, paler beneath, 5–6 mm. long, 2·25–3 mm. wide.

Stem herbaceous, procumbent at the base or creeping, with erect flowering stems; primary internodes undeveloped.

Leaves radical and cauline, alternate (first two opposite or equally developed), more or less hairy or tomentose when young, minutely scaly, deep greyish-green; petioles semiterete, deeply channelled above, dilated and clasping at the base, more or less hairy.

Nos. 1 and 2. Opposite, spathulate, acute, tapering into the petiole, always having one to two subulate, acute teeth on each side.

Ultimate leaves oblanceolate-linear in outline, two to four times pinnatisect primary and secondary segments or divisions ovate; tertiary and quaternary divisions slender, subulate or lanceolate, acute, more or less acuminate or subaristate.

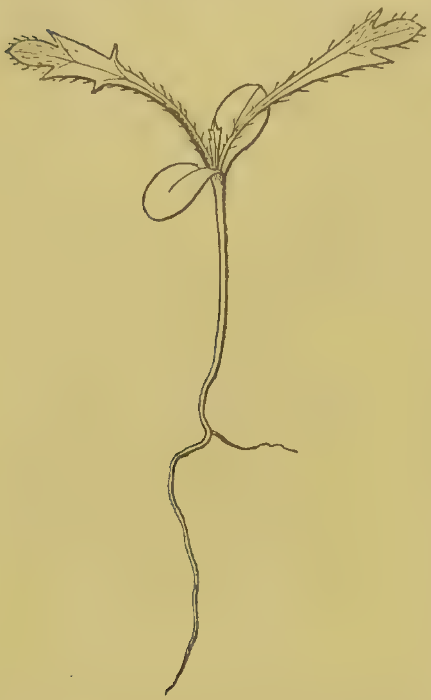

FIG. 470.—*Achillea Millefolium*, × 2.

Anthemis sp. (fig. 471).

Primary root comparatively short, tapering rather suddenly to a fine point and giving off long, lateral, adventitious roots.

Hypocotyl terete, glabrous, twisted very frequently or curved, pale green, almost colourless, 1–1·5 cm. long.

Cotyledons shortly linear-oblong, obtuse, 5–6 mm. long, 2 mm. wide.

Stem herbaceous, terete or slightly angular, glabrous or minutely scabrous on the slender ridges, pale green; 1st internode 2 mm. long; 2nd undeveloped; 3rd 3·5 mm.; 4th 2 mm.

Leaves multisect, alternate, with amplexicaul petioles, pale green, odorous, glabrous or minutely and sparsely pubescent, chiefly on the nerves.

Nos. 1 and 2. Almost or quite opposite; lamina oblong, pinnati-fid or -sect, with lanceolate, acute segments; petiole flat above, convex beneath, 1·3 cm. long.

No. 3. Pinnatisect; lower segments small, linear, acute, entire; upper segments lanceolate, acute, frequently cut again.

Nos. 4–6. Bipinnatisect with slender, linear-lanceolate, acute or bristle-tipped segments.

These characters are fairly constant throughout a great number of seedlings.

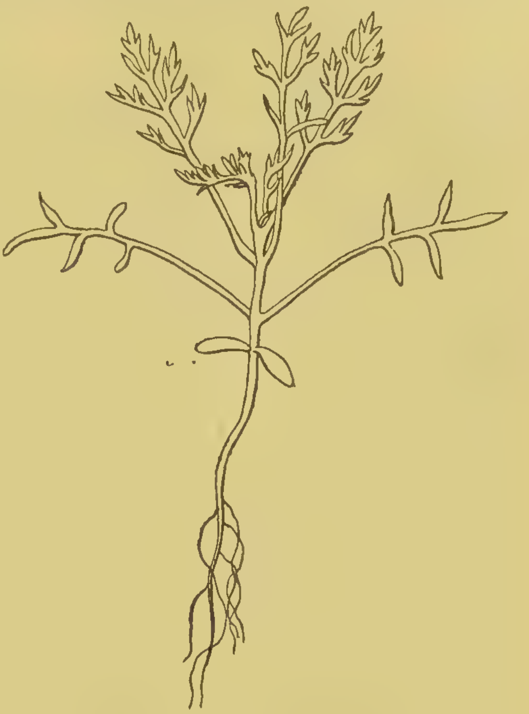

FIG. 471.—*Anthemis sp.* Nat. size.

Anthemis mixta, *L.*

Primary root slender and fibrous.

Hypocotyl erect, terete, glabrous, reddish, 1–1·5 cm. long.

Cotyledons linear-spathulate, tapering to a narrow petiole-like base, obtuse, slightly connate at the base, glabrous, 1–1·6 cm. long, 2–2·5 mm. at the widest.

Stem herbaceous, erect, terete, glabrous; 1st internode 2–12 mm. long, according to circumstances, and whether the seedlings are crowded or not.

Leaves alternate (first pair opposite), sessile, glabrous, uni- to bipinnatisect, more or less sheathing or clasping at the base.

First pair opposite, entire, long, slender, linear, acute, convex above and obtusely carinate beneath, narrower than the cotyledons and several times longer.

No. 3. Pinnatisect with a few distant, linear, acute segments by far the longest towards the apex of the leaf.

No. 4. Similar, rather more divided.

Nos. 5–7. Two to three times pinnatisect; ultimate segments linear or linear-lanceolate, acute.

Chrysanthemum carinatum, *Schousb.* (fig. 472).

Primary root long, tapering, flexuose, giving off long lateral fibres.

Hypocotyl erect, 3–5 cm. long, 2 mm. thick, herbaceous, glabrous, shining, pale, slightly suffused with purple.

Cotyledons oblong, obtuse, fleshy, convex above, subrevolute at the margins, 1–1·5 cm. long.

Stem herbaceous, annual.

Leaves.—Nos. 1 and 2. Linear, obtuse, distantly toothed or lobed about the middle of the lamina, amplexicaul at the base.

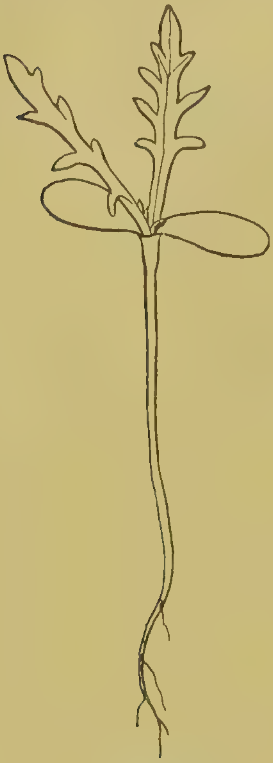

FIG. 472.
Chrysanthemum carinatum. Nat. size.

No. 3. Linear-oblong, pinnatifid; lobes obtuse.

No. 4. Oblong, pinnatifid; lobes oblong, subacute or mucronate, fleshy.

No. 5. Similar, larger and toothed along the narrow petiole-like part to the amplexicaul base.

No. 6. Oblong in the upper part and pinnatisect, otherwise like No. 5.

No. 7. Pinnatisect; lobes pinnatifid or toothed. This and the younger leaves more or less glandular on the upper surface.

Chrysanthemum segetum, *L.*

Primary root as in last species, annual.

Hypocotyl fleshy, colourless, tapering into the root, 1·65 cm. long.

Cotyledons very similar to those of the last species, 1·35 cm. long, 4·5 mm. thick.

Stem herbaceous, annual.

Leaves simple, radical and cauline, opposite, sessile, glabrous, more or less lobed or pinnatifid, subglaucous-green above, paler beneath.

First pair oblong, obtuse, deeply toothed with obtuse or acute, apiculate teeth, decurrent on the broad petiole-like base; margin entire; midrib prominent.

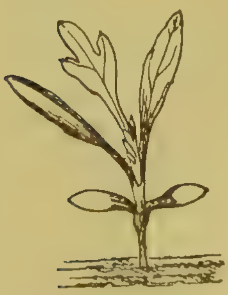

FIG 473.
Matricaria nigellæfolia. Nat. size.

Second pair oblong, obtuse, pinnatifid, decurrent and serrate on the broad petiole-like base; lobes oblong, obtuse, dentate-serrate with obtuse or acute, apiculate serratures.

Matricaria nigellæfolia, *DC.* (fig. 473).

Hypocotyl erect, terete, glabrous, 2–5 mm. long, light green.

Cotyledons spathulate, obtuse, entire, sessile, but tapering towards the base, glabrous, 4–6 mm. long, light green.

Stem erect, short, herbaceous.

Leaves.—First pair opposite (the others alternate), entire, cauline, linear-lanceolate, rather obtuse, tapering at the base, glabrous, glaucous-green, midrib with numerous ascending branches.

Second and third pairs alternate, and tri-lobed or -fid.

Matricaria Parthenium, *L.*

Primary root long, tapering, flexuose, with numerous lateral rootlets.

Hypocotyl short, stout, merging into and indistinguishable from the root.

Cotyledons small, subobovate, sessile, 5 mm. long, 3 mm. wide.

Stem herbaceous, elongated when about to flower.

Leaves simple, radical and ultimately cauline, alternate; pubescent on both surfaces, and densely covered with sessile glands, highly odorous, more or less pinnately divided; petioles pubescent, channelled above, dilated and amplexicaul at the base.

No. 1. Spathulate, entire or one-toothed.

No. 2. Cuneate, obtuse, trifid or merely toothed.

No. 3. Shortly and broadly oblong, pinnatifid.

No. 4. Triangular, pinnatifid.

No. 5. Pinnatifid, or pinnatipartite; lobes subcuneate, toothed at the apex, or slightly cut.

No. 6. Triangular, obtuse, pinnatipartite; lobes subpinnatifid or toothed.

No. 7. Ditto; but lobes alternate, ovate and oblong, deeply pinnatifid.

Nos. 8 and 9. Triangular, almost pinnatisect; lobes ovate, pinnatifid and toothed, lower ones deeply cut on the basal, posterior side.

The *var.* laciniatum has its larger leaves pinnatisect, pinnatipartite and pinnatifid; ultimate segments subulate or lanceolate, and acute.

Matricaria globifera, *Fzl.*

Hypocotyl as in M. Parthenium, subterranean.

Cotyledons falling away early.

Stem herbaceous, erect, terete, slightly pubescent; internodes crowded or many of the lower ones undeveloped.

Leaves simple, ultimately pinnately multisect, radical and cauline, lower petiolate, upper sessile, glabrous, deep green with the segments convex above, minutely revolute at the margins, making a shallow channel on each side of the rather prominent midrib in the primary divisions,—the midrib is absent in the smaller divisions; petioles glabrous, flattened on the upper surface or convex, dilated and slightly channelled at the amplexicaul base, convex or deepening into a ridge beneath.

Nos. 1 and 2. Small, spathulate-cuneate, and five-toothed.

Nos. 3 and 4. Pinnatifid, short, subcuneate at the base, with entire segments.

No. 5. Short, broad, irregularly bipinnatifid.

No. 6. Bipinnatisect, the lower segments scattered.

No. 7. Shortly oblong, obtuse, bipinnatisect; lowest segment small.

No. 8. Ditto, tripinnatisect; middle segment largest and most cut.

No. 9. Oblong, obtuse, tripinnatisect with most of the primary divisions nearly equal; base of petiole with a few linear segments.

Nos. 10 and 11. Oblong, obtuse, tri- to quadri-pinnatisect, with a small detached segment about the middle of the petiole, and a few linear, mostly entire ones towards or close to the base; ultimate segments linear, acute rather thin but fleshy.

Cauline leaves sessile; larger ones bi- to tri-pinnatisect to the very base with mostly alternate segments—the middle ones largest with long, linear, slender, subfiliform acute segments.

Cotula coronopifolia, *L.*

Hypocotyl slender, 8–10 mm. long.

Cotyledons oblong or linear-oblong, obtuse, or slightly spathulate, entire, connate into a cylindrical sheath at the base for about one-third of their length, and surrounding the plumule, glabrous, sessile, a midrib faintly visible, 3–4·5 mm. long in the upper free part, and 1·5–2 mm. wide.

Stem terete, glabrous; 1st internode ·9–1·5 cm. long; 2nd shorter and often entirely covered with the leaf-sheaths.

Leaves simple, cauline, alternate (first pair opposite), sheathing at the base, glabrous, at least in the seedling.

Nos. 1 and 2. Opposite, linear, entire, obtuse, elongated, tapering to the base, indistinctly petiolate, but sheathing the stem with a cylinder from 3–4·5 mm. long, showing a midrib only, minutely punctate.

No. 3. Similar, and sheathing in the same way, entire or with a narrow linear, lateral segment, about or below the middle.

No. 4. Similar to the last or having a segment on each side, the segments being alternate.

Cenia subheterocarpa, *Less.*

Leaves simple, uni- to bi-pinnatifid, cauline, lower opposite, upper alternate, sessile, hairy on both surfaces.

First pair opposite, linear, slender, entire.

Second pair opposite, pinnatisect, linear-oblong in outline.

Third pair opposite, linear-oblong, pinnatisect with the segments pinnatifid in the upper half.

Fourth pair pinnatisect, segments pinnatifid.

Nos. 9-11. Alternate, pinnatisect, segments pinnatifid; ultimate divisions linear-lanceolate, acute, small.

Ultimate leaves oblong-linear, pinnatisect in the lower third, with slender, linear, acute segments, pinnatisect, segments again pinnatifid in the upper two-thirds, with subulate, lanceolate, acute divisions.

Pentzia virgata, *Less.*

Hypocotyl erect, or more or less decumbent, terete, glabrous, pale green, 5–10 mm. above the soil.

Cotyledons spathulate-oblong, obtuse, entire, glabrous, light green, sessile, 3·5–4 mm. long, 1·25–1·75 mm. wide.

Stem erect, terete, silky or almost hoary from loose or adpressed hairs, ultimately becoming shrubby; internodes short and several of the primary ones hardly developed.

Leaves simple, cauline, alternate, more or less hoary with cottony, loosely adpressed hairs, light green when young, ultimately pinnatisect, with alternate segments corresponding to the venation; petioles channelled above in the lower half, convex on the back, dilated towards the base and semiamplexicaul, hairy, pale green.

Nos. 1 and 2. Linear, subacute or obtuse, entire, slightly wider towards the top and narrowed to the base, or petiolate.

Nos. 3–6. Cuneate, trifid at apex, with acute segments, long, petiolate.

Nos. 7–9. Pinnati-fid or -sect, with one or two lateral and one terminal segment; segments linear, acute.

Nos. 10–12. Similar but with more numerous pinnæ.

Nos. 13–17. Pinnatisect, pinnatifid; ultimate segments linear-lanceolate or subulate, acute.

Artemisia annua, *L.*

Primary root normal, with a few lateral fibres.

Hypocotyl tapering into and indistinguishable from the root, colourless, fleshy.

Cotyledons small, shortly oblong, obtuse, 2·5 mm. long, 1·5 mm. wide.

Stem developed when about to flower, herbaceous, annual.

Leaves simple, radical and cauline, alternate, thinly pubescent, bright green above, paler beneath and rather prominently nerved, ultimately multisect; petioles channelled above, dilated at the base, and after the leaves have attained some size auricled with irregularly cut laciniæ.

Nos. 1 and 2. Small, spathulate-cuneate, tridentate at the apex.

No. 3. Cuneate, obtusely five-toothed.

No. 4. Shortly and broadly oblong, five-lobed; lobes obtuse, mostly bidentate.

No. 5. Oblong-ovate, obtuse, pinnatifid; lobes subcuneate, dentate.

No. 6. Triangular-ovate, obtuse, pinnatisect; lower lobes pinnatifid on the posterior side, coarsely dentate; upper lobes coarsely dentate.

No. 7. Triangular-ovate, pinnatisect; lobes pinnatifid and dentate.

Radical leaves numerous, ultimately triangular, bipinnatisect, ultimate segments pinnati-fid to -partite; primary segments oblong—the lower two longest; secondary segments oblong, most developed on the posterior side of the primary segments; ultimate divisions oblong, cuspidate, entire, or the larger ones dentate.

Artemisia Mutellina, *Vill.*

Hypocotyl erect, terete, 3–5 mm. above ground.

Cotyledons linear-spathulate, obtuse, entire, glabrous, sessile, recurved, 4–5 mm. long, 1·5–1·75 mm. wide.

Stem herbaceous, erect, terete, nearly or quite glabrous in the young state, and then having the primary internodes undeveloped, or the first 2–3 mm. long, and the succeeding ones shorter.

Leaves hoary, with a silky adpressed pubescence, tapering gradually into the petioles; petiole flattened above or biconvex.

Nos. 1–4 or 5. Linear, entire, acute, the third to fifth slightly broader above the middle. In strong seedlings the fourth and fifth may be unequally bifid or subequally trifid.

Nos. 6–10. Trifid with linear, obtuse, or subacute segments, the terminal one being longest.

Tussilago Farfara, *L.* (fig. 474).

Primary root tapering, flexuose, soon supplanted by strong lateral roots from the base of the hypocotyl.

Hypocotyl very short, subterranean, reddish.

Cotyledons linear-oblong, obtuse, fleshy, shortly petiolate, dilated at the base, amplexicaul and subconnate, 5 mm. long including the petiole.

Stem creeping, subterranean.

Leaves simple, radical, alternate, fleshy, obscurely subpalmatinerved, white and cottony above when young, felted with a white cottony tomentum beneath; petioles semiterete, channelled on the upper side, at first cottony, ultimately nearly glabrous.

No. 1. Small, spathulate, obtuse, entire, mucronate.

No. 2. Ovate, with a tooth on each side or in stronger seedlings broadly ovate with two teeth on each side, mucronate.

No. 3. Similar to the last or in robust seedlings broadly ovate or triangular, obtusely five-angled, obscurely five-nerved.

No. 4. Cordate, obtusely seven-angled and sparingly and obscurely toothed between the angles.

No. 5. Similar, but more decidedly toothed between the angles.

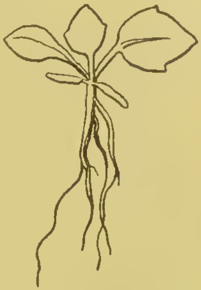

FIG. 474. *Tussilago Farfara.* Nat. size.

Senecio cruentus, *DC.*

Achene terete, or the outer ones slightly compressed, longitudinally ribbed, and minutely transversely wrinkled or marked, glabrous, but covered between the ridges with a double row of white papillæ, dark brown, crowned with the easily removable bristly or setaceous pappus, slightly contracted at the top and forming a little cup on which the pappus is seated.

Seed closely conforming to the achene; testa thin, brownish; hilum and micropyle contiguous, basal; chalaza apical.

Endosperm absent.

Embryo straight, conforming to the shape of the seed, and occupying the whole of the interior, pale yellow or nearly colourless; cotyledons oblong, obtuse or rounded at the apex, entire, tapering into the radicle at the base and not auricled; radicle short, about half the length of the cotyledons, turbinate at the tip, obtuse, sometimes slightly contracted at the base of the cotyledons, close to the micropyle.

Seedling.

Hypocotyl very short.

Cotyledons oblong-ovate or subrotund-ovate, obtuse, subemarginate, mucronulate, fleshy, pale green above, tinted with violet beneath, glabrous; lamina 7 mm. long, 6 mm. wide; petiole flattened, glabrous, 5 mm. long.

Stem herbaceous, elongated when about to flower.

Leaves simple, radical and cauline, dull green and thinly hairy above, green or more often violet beneath, and very hairy, palmately five- to seven-nerved at the base and alternately penninerved upwards; petioles semiterete, channelled above, dilated and amplexicaul at the base, densely hairy or villous.

No. 1. Cordate, obtuse, five-nerved, distantly dentate with triangular, mucronate teeth.

Nos. 2 and 3. Cordate, acute, five- to seven-nerved at the base, coarsely dentate with occasional smaller intermediate teeth, deeply auricled at the base; teeth mucronate. The ultimate leaves differ little except in size.

Senecio erucæfolius, *Huds.*

Achene oblong-cylindrical, narrowed at the very base, constricted immediately beneath the base of the pappus, pubescent with lines of short ascending hairs; pappus copious, with thinly puberulous hairs.

Seed oblong, obtuse, narrowed slightly to the base, smooth, pale brown; hilum small, basal; raphe forming a deeper brown line along one side to the apex of the seed.

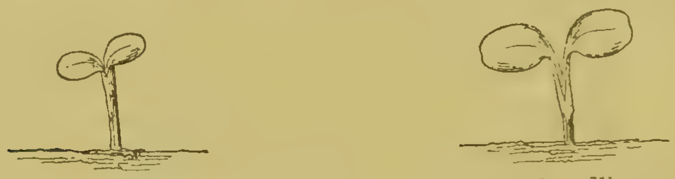

FIG. 475.—*Senecio erucæfolius.* Two stages of seedling.

Endosperm absent.

Embryo colourless; cotyledons as in S. cruentus; radicle stout, obtuse, close to the base of the seed, slightly narrower than the cotyledons, but about equal in length.

Seedling (fig. 475).

Hypocotyl glabrous, 5–8 mm. long.

Cotyledons immediately after germination small, oval, obtuse or rounded at both ends, entire. After they have become three or four times as large, they are still oval but emarginate. Finally they become rotund, deeply emarginate, and 5–7 mm. long and wide.

The apex has three or four large open pores, which are visible under the microscope at an early stage and continue more or less distinct till the cotyledon becomes old and thick.

The cotyledon is trinerved immediately after germination. The lateral nerves and midrib are distinct in both lamina and petiole, and are continued down to the vascular bundles of the hypocotyl;

in the lamina they curve round nearly parallel within the margin, but are more or less irregular or undulated, and unite with the midrib close to the apical sinus. The midrib is also undulated or zigzag, and gives off from its angles alternate, ascending, lateral branches that unite with the lateral nerves and form a series of large reticulations.

Stomata on the under surface tolerably numerous and large; few on the upper surface, but similar to those on the under.

Stem herbaceous and elongated when about to flower.

Leaves simple, radical and cauline, petiolate or sessile towards the upper part of the stem, glabrous in the seedling, pubescent and cottony above in the adult plant, densely pubescent beneath; petioles somewhat channelled above, dilated and clasping at the base, gradually becoming shorter on the stem till the leaves are sessile.

Nos. 1 and 2. Oval, obtuse, entire, with a few alternate, ascending nerves, glabrous, bright green.

The leaves on the lower part of the stem are oblong, obtuse, pinnatifid, or coarsely dentate. The median ones are sessile, oblong, obtuse, narrowed to the base, pinnatisect: segments oblong, obtuse, more or less coarsely dentate or incise-dentate principally on the posterior side. The upper ones are shorter, sessile, much less narrowed at the base, pinnatisect with linear or oblong segments, again subpinnatifid or coarsely cut, especially on the posterior side.

Senecio pulcher, *Hook. et Arn.*

Primary root stout, colourless, tapering downwards, with lateral, adventitious roots which soon become stronger than itself.

Hypocotyl undeveloped.

Cotyledons broadly ovate-oblong, obtuse, minutely emarginate, fleshy, petiolate; venation obscure, comprising a midrib with irregular lateral branches which branch again, anastomose and unite with a slender submarginal nerve, glabrous, deep green, suffused with violet beneath; lamina 1–1·8 cm. long, 7–10 mm. wide; petiole semiterete, flattened above or shallowly grooved, dilated and connate at the base, 1·1–1·9 cm. long.

Stem herbaceous, and developed when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline; venation irregular; nerves alternate and incurving, obscurely reticulate, deep opaque green above, paler, but often suffused with violet beneath, glabrous; petiole semiterete, grooved above, dilated and clasping at the base, glabrous.

No. 1. Broadly oval or rotund-oval, obtuse, obsoletely dentate.

No. 2. Similar, but more decidedly serrate-dentate.

Ultimate leaves oblong or oblong-elliptic, unequally dentate or frequently lobulate, fleshy, alternately penninerved, glabrous or slightly woolly at the margin, with long petioles.

Senecio tetranthus, *DC.*

Hypocotyl erect, becoming stouter upwards, glabrous, almost colourless or reddish, 5–7 mm. long.

Cotyledons oval, obtuse, entire, generally tipped with a small mucro, glabrous, with a barely discernible midrib seen only by transmitted light; lamina 5–6 mm. long, 3·25–4·25 mm. wide; petiole flat above or slightly grooved, convex on the back, 4–6 mm. long.

Leaves simple, radical and cauline, alternately and ascendingly penninerved, hairy all over, light green; petiole semiterete, channelled above, coarsely hairy all over with many-jointed, whitish hairs, dilated and clasping at the base.

No. 1. Broadly ovate, cuspidately subacute, with a few glandular-mucronate teeth on each side, and alternate, bent or wavy nerves not running directly into the teeth.

Senecio vulgaris, *L.*

Primary root normal with numerous lateral rootlets.

Hypocotyl erect, terete, succulent, deep purple and shining, about 8 mm. long.

Cotyledons oblong-spathulate, obtuse, entire, tipped with a glandular mucro, trinerved, with the lateral nerves parallel with, and close to the margin, incurved and uniting with the midrib close to the apex; midrib giving off lateral, alternate short branches ascending irregularly, and forming a series of reticulations with the lateral nerves. The stomata are about equal in number on both surfaces, and the epidermal cells very wavy in outline. At the very tip of the cotyledon and at its apical edge are some large open pores in the glandular mucro. There are no openings on the upper or under surface corresponding to those close to the apex in Galium Aparine and Lithospermum officinale.

Stem herbaceous, annual, fleshy, erect, terete at the base, angled and furrowed upwards, sparsely hairy or woolly when young, ultimately almost or quite glabrous; 1st internode 4 mm. long; 2nd 2 mm.; 3rd 10 mm.; 4th undeveloped; 5th 8 mm.; 6th 5 mm.

Leaves cauline, lower petiolate, upper sessile, woolly or hairy at the base on both sides when young like the buds, ultimately glabrous or nearly so, deep green above, paler or subglaucous beneath; lower petioles as well as the midribs of the sessile leaves grooved on the upper side, dilated at the base and amplexicaul.

No. 1. Spathulate, obsoletely serrate.

No. 2. Similar, but oblong-spathulate.

Nos. 3 and 4. Oblong-spathulate, irregularly doubly dentate.

No. 5. Spathulate, oblong, pinnatifid and dentate, sessile, subauricled at the base.

No. 6. Oblong, broadest at the apex, auricled at the base, sessile, more deeply pinnatifid and dentate than No. 5.

No. 7. Sublyrate, deeply pinnatifid, and irregularly incise-dentate, narrowed to the base, but sessile, auricled and decurrent on the stem.

Nos. 8–10. Deeply lyrate-pinnatifid, with linear-oblong, deeply dentate or cut segments, almost bipinnatifid, sessile, auricled and subdecurrent; margins revolute.

Senecio squalidus, *L.*

Primary root tapering downwards with numerous adventitious fibrous rootlets, colourless.

Hypocotyl 2 cm. long, ·75–1 mm. thick, becoming thickened upwards, deep dull purple.

Cotyledons spathulate, entire, petiolate, 1·3 cm. long; limb 3 mm. wide, glabrous, green, suffused with purple beneath.

Leaves cauline, petiolate, thinly pubescent on both sides, deep green above and more or less suffused with purple beneath.

No. 1. Oval, sometimes spathulate, obtuse, and cuneate at the base, obsoletely serrate; petiole somewhat dilated at the base and subamplexicaul, more or less pubescent, especially at the edges, channelled above.

No. 2. Oval, obtuse, obtusely and distantly serrate.

No. 3. Oblong, obtuse, lobed; lobes short, subserrate.

No. 4. Oblong, obtuse, more deeply lobed than the last; lobes subserrate, penninerved with alternate nerves.

No. 5. Oblong, pinnatifid, obtuse; lobes more decidedly serrate.

The stem in the young state is covered by the semisheathing petioles.

Senecio viscosus, *L.*

Hypocotyl terete, about 4 mm. long, glabrous, deep purplish-red.

Cotyledons spathulate, obtuse, entire, glabrous; petiole slightly channelled above, 8–10 mm. long.

Leaves radical in the seedling; petiole subamplexicaul, channelled above, hairy with glandular jointed hairs; limb hairy on both sides with glandular jointed hairs.

No. 1. Oval, obtuse, obscurely penninerved, obsoletely dentate-serrate; each serrature tipped with a gland or mucro.

No. 2. More distinctly dentate-serrate, oval.

No. 3. With broadly triangular, shallow and gland-tipped serratures, broadly oblong, obtuse.

Senecio elegans, *L.* (fig. 476).

Primary root tapering, with numerous lateral rootlets, annual.

Hypocotyl erect, terete, greenish, succulent, 1·25 cm. long.

Cotyledons spathulate-oblong, obtuse, subfleshy, 9 mm. to 1·2 cm. long, 2–3 mm. wide, glabrous.

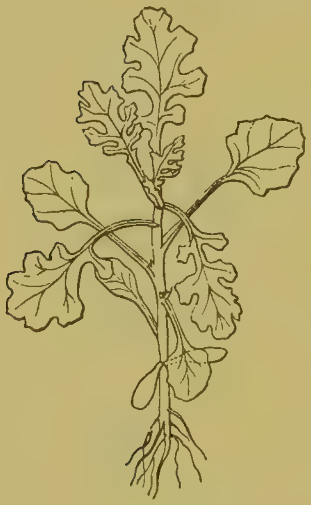

FIG. 476.—*Senecio elegans.* Half nat. size.

Stem herbaceous, annual.

Leaves cauline, sparsely hairy at least when young; lamina subdecurrent on the petiole; petiole channelled above, convex beneath, hairy at the margin, dilated and sheathing at the base.

No. 1. Rotund, obsoletely dentate-serrate.

No. 2. Subobovate, obtusely dentate.

No. 3. Larger and foreshadowing division at the base.

No. 4. Broadly oblong, obovate, obtusely and shallowly lobate.

No. 5. Irregularly pinnatifid, with a small lateral obovate lobe, and a large unequally triangular, obtuse, shallowly lobulate terminal segment; lobes very obtuse, obsoletely mucronate-dentate along the ends, revolute at the margin.

No. 6. Similar with two small alternate, lateral segments, revolute at the margin.

No. 7. Lyrate-pinnatifid, revolute at the margin, with four alternate segments; terminal segment much smaller than in the preceding leaves; lobes angled or dentate along the apex.

No. 8. Lyrate-pinnatifid, oblanceolate in outline, revolute at the margin; segments gradually smaller from the terminal, to the very small, basal ones, angled and mucronately dentate along the ends.

Senecio neelgherianus, *DC.*

Cotyledons spathulate, obtuse, tapering to the base, glabrous, pale green, 1·1 cm. long, 4·5 mm. wide.

Stem subshrubby, erect, terete, slightly flexuose near the base, dull purple and densely covered with spreading jointed white hairs; 1st internode 7 mm. long; 2nd 7·5 mm.; 3rd 7 mm.; 4th 7·5 mm.; 5th 9·5 mm.; 6th 13·5 mm.; 7th 10·5 mm.; 8th 8 mm.; 9th 5 mm.

Leaves cauline, sessile, densely covered on both surfaces with spreading or patent, jointed, white hairs, ascending, patent, or older ones recurved, revolute at the margin from the fourth onward.

No. 1. Spathulate, entire, or obsoletely denticulate, 1·75 cm. long, 9 mm. wide above the middle, tapering to a narrow base.

No. 2. Spathulate, tapering to a narrow base, obsoletely and mucronately dentate.

No. 3. Spathulate, subserrate above the middle, tapering to a rather broad base.

No. 4. Broadly spathulate or subobovate, more decidedly serrate above the middle.

No. 5. Broadly spathulate, serrate above the middle, tapering to a broad base.

No. 6. Spathulate, with a broad base, serrate nearly throughout, apex subacute.

No. 7. Spathulate, acute, serrated to the base and subauricled; serratures largest above the middle of the leaf.

Nos. 8–12. Spathulate, acute, serrate throughout, auricled at the base and amplexicaul.

Senecio speciosus, *Willd.*

Primary root slender, tapering, much branched, with long, slender, very numerous rootlets, at length overpowered by strong adventitious roots arising immediately below the leaves.

Cotyledons spathulate, obtuse, glabrous, rather succulent, pale green, 1 cm. long, tapering gradually into the connate petiole; petioles ascending, 7 mm. long.

Leaves radical, coarsely hairy on both sides and villous on the midrib beneath; pale green above and paler beneath.

No. 1. Rotund, entire, obscurely trinerved, and suddenly tapering into a broad channelled petiole; petiole subvillous, dilated and sheathing at the base.

No. 2. Broadly elliptic and rounded at the apex, distantly and obsoletely dentate at the sides, otherwise like the first.

No. 3. Obovate, obtuse, distantly serrate-dentate, obscurely penninerved.

Nos. 4 and 5. More decidedly serrate; serratures obtuse, submucronate.

Ultimate leaves linear-oblong, pinnatifid; lobes shortly oblong, toothed in an irregular or jagged manner; apex and long sub-channelled base irregularly toothed, not lobed.

Senecio polycephalus, *Ledeb.*

Hypocotyl subterranean or none.

Cotyledons as in S. speciosus but with a distinct petiole, about 1·3 cm. long including the petiole; lamina 5 mm. wide.

Leaves radical in young specimen, covered on both surfaces of the petiole and lamina with coarse, jointed, subglandular hairs; petiole subamplexicaul at the base.

No. 1. Ovate-oblong, obtuse, obsoletely dentate-serrate; petiole channelled above, convex below, about 1 cm. long.

No. 2. Oblong, obtuse, cuneate at the base, distantly dentate-serrate, with broadly triangular acute or mucronate serratures, suffused with purple on the under surface.

No. 3. Oblong, apex mucronate, otherwise similar to No. 2.

Gamolepis Tagetes, *DC.*

Primary root short, tapering, flexuose, throwing out strong branches at an early stage, which soon supersede it.

Hypocotyl suberect, terete, glabrous, deep purple, 1·8 cm. long, 1·25–1·5 mm. thick.

Cotyledons oval, obtuse, shortly petiolate, glabrous, deep purple; lamina 7 mm. long, 5·5 mm. wide; petiole 2·5 mm. long.

Stem herbaceous, annual, erect, glabrous, with angles decurrent from the base of the petioles; 1st internode 2 mm. long; 2nd 1 mm.; 3rd 3 mm.; 4th 3 mm.; 5th 6·5 mm.; 6th 1·6 cm.; 7th 2·2 cm.

Leaves simple, pinnatisect (after the first one), cauline, glabrous; petioles fleshy, channelled above, dilated at the base and amplexicaul.

No. 1. Tripartite, subcuneate, with flat, linear segments.

No. 2. Pinnatisect; segments in three nearly opposite pairs with a terminal one, flat, linear, subacute.

No. 3. Segments seven, fleshy.

No. 4. Segments nine, alternate, fleshy, frequently with a tooth on the posterior side.

Nos. 5 and 6. Segments linear, slightly dilated upwards, fleshy, slightly channelled on the upper side, frequently folded up face to face.

Gamolepis annua, *Less.*

Hypocotyl erect, terete, slightly hoary, 1·5-2 mm. long, reddish-green, minutely pubescent.

Cotyledons ovate-oblong, obtuse, very slightly emarginate, fleshy, somewhat incurved, light green above, tinged with red below, glabrous, one-nerved, with short petioles.

Stem short, erect, herbaceous; primary internodes very slightly developed.

First leaves simple, deeply pinnatifid, petiolate; segments opposite, sessile, linear, acute, glabrous, light green, one-nerved.

Calendula officinalis, *L.*

Achene polymorphic—those of the ray incurved, in two to three series, varying greatly in length and outline, muricate on the back, pubescent, the outermost ones often narrow and greatly elongated or drawn out into a beak, and more or less produced into a hooklike appendage at the base. The next set within this is similar but furnished with broad wings, which are involute at the margin and more or less pubescent as well as muricate; the inner ones are strongly incurved, often forming a complete ring, narrowly winged with the wings involute at the margin, or wingless, short, muricate at the back, smooth on the ventral face, with the hooklike appendage still present at the base.

Seed terete or oblanceolate, and tapering to the base, more or less compressed dorso-ventrally, and conforming to the outline of the achene, glabrous; testa thin, pale, membranous; hilum and micropyle inferior, contiguous; chalaza apical, superior.

Endosperm absent.

Embryo large and filling the entire seed, colourless, more or less curved in conformity with the achene and seed; cotyledons spathulate, obtuse, entire, or the outer dorsal one sometimes minutely emarginate, tapering into the radicle and lying in the broader diameter of the seed with their backs to the axis or centre of the disc, plano-convex, subfleshy; radicle tapering to an obtuse point, lying in the narrow basal part of the seed, about half the length of the cotyledons or less.

Germination.

A. The outermost achenes of the capitulum.

The radicle pushes out at the base of the fruit, and the energy of the swelling cotyledons is sufficient to split the achene into two or three valves longitudinally, that is, dorso-ventrally, or along the back and along the front on either side of the basal hook-like process. The hypocotyl has then no difficulty in extricating the cotyledons. If moderately covered with soil during germination, the seed is so loaded owing to the extent of its superficial area, that it is rarely carried up on the cotyledons. The cotyledons when they emerge are oblong, obtuse, entire, and narrowed to the base. Of twelve fruits of this series sown, seven germinated, or 58·3 per cent.

B (fig. 477). The achenes from the middle series of the capitulum are more or less broadly winged. The radicle pushes out at the base of the fruit apparently most frequently on the ventral aspect, and not being able to get clear of the infolded margin of the wing, runs along the groove, and emerging at the apical end of the achene enters the soil, fixing down the achene while the hypocotyl pulls the cotyledons out. The achene splits longitudinally as in outer fruits of the receptacle into three valves, and seems to be rarely, if ever, carried up by the cotyledons. The figure shows the seedling two days after germination commenced.

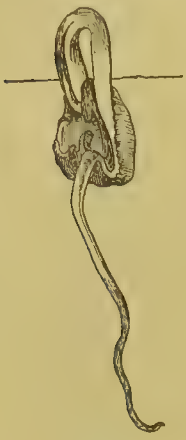
FIG. 477. *Calendula officinalis*, × 1½. Germination.

Of twelve fruits sown, nine germinated, or 75 per cent.

C. The innermost achenes of the capitulum are much curved. In germination they become deeply split, and the hypocotyl in elongating and straightening pulls the cotyledons out. The achene is sometimes carried up on the cotyledons, which immediately after emergence are narrowly spathulate-oblong, obtuse, entire, narrowed to the base, glabrous, pale yellowish-green. Of twelve fruits of this series, nine germinated, or 75 per cent.

Calendula hybrida, *L.*

Achene dimorphic, obovate-oblong, flattened and furnished with a broad membranous wing, or scarcely flattened and wingless with rows of teeth.

Seed conforming to the shape of the fruit, exalbuminous, 8–10 mm. long; testa membranous, smooth; hilum inconspicuous.

Embryo straight, filling the whole seed, dirty grey; cotyledons linear, obtuse, entire, rather thick, closely adpressed, lying the broad way of the seed; radicle tapering downwards, subacute, much shorter than the cotyledons.

Calendula pluvialis, *L.*

Achene dimorphic, some winged, broadly obovate or subrotund, (including wings), considerably flattened, smooth and brown; the others wingless, obovate, scarcely flattened, tubercled, black.

Seed conforming to the shape of the fruit, 4–5 mm. long; testa thin, membranous; hilum inconspicuous.

Embryo straight, filling the seed, colourless; cotyledons linear or linear-oblong, obtuse, entire, closely adpressed, lying the broad way of the seed; radicle tapering to the base, acute.

Calendula algarbiensis, *Boiss.*

Achene at least trimorphic; those of the outer whorl linear-oblong, straight or slightly curved, wingless, covered with glandular hairs, 5–5·5 mm. long, surmounted by a beak from 5–7 mm. in length.

The second whorl consists of curved fruits, often forming a complete coil, winged, the wings bent downwards, covered with about three rows of pointed tubercles, and slightly glandular-hairy, 3·5–4 mm. in diameter.

The third whorl consists of wingless coiled fruits, forming almost a closed curve 2·5–3 mm. in diameter, extremely rugose, without hairs.

The fourth whorl is similar to the third, but the fruits are much smaller, being about 1 mm. long, and the coil is not closed.

Ursinia speciosa, *DC.* (fig. 478).

Achene cylindrical-clavate, somewhat curved about the middle and narrowed at the base, longitudinally ten-ridged with the ridges in five contiguous pairs, transversely and minutely rugose, brown, surrounded at the base with white cottony hairs, and surmounted by a paleaceous pappus consisting of five ovate, obtuse pieces, hyaline or white and penninerved, with a linear-lanceolate, acute, pale brown midrib.

Seed basal, erect, conforming in outline to that of the achene, prolonged at the base; testa membranous, pale, much thinner; hilum basal; chalaza apical.

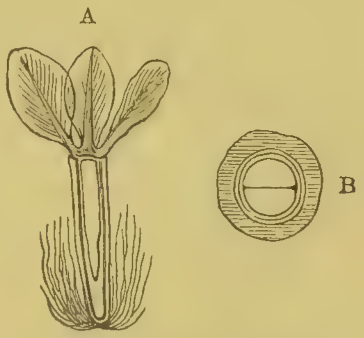

Fig. 478.—*Ursinia speciosa.* A, longitudinal section of achene, × 2½. B, transverse section of achene, × 5.

Endosperm absent.

Embryo slightly curved, owing to the curve of the achene, large and filling the interior of the seed to which it conforms; cotyledons linear-spathulate, narrow, truncate at the apex or rounded, or incipiently emarginate; radicle tapered to a narrow or subacute point, a little shorter than the cotyledons.

Seedling.

Primary root tapering downwards, wiry, flexuose, colourless, annual.

Hypocotyl ascending or erect, terete, glabrous, about 1·1 cm. long, purplish-green.

Cotyledons linear, obtuse, entire, fleshy, glabrous, persistent and green, 1·5 cm. long.

Stem herbaceous, annual, erect, angled, glabrous, pale green, shining; 1st internode 3·5 mm. long; 2nd 5·5 mm.; 3rd 1 mm.; 4th 1·4 cm.; 5th 5·5 mm.; 6th 1·65 cm.; 7th 1·45 cm.; 8th 1·35 cm.; 9th 1·45 cm.

Leaves simple, alternate (first two opposite), glabrous, deep green, fleshy, pinnatisect; petioles channelled above, convex or subcarinate beneath, the lower dilated and semiamplexicaul at the base, the upper amplexicaul, and auricled with a number of filiform, slender, acute laciniæ.

Nos. 1 and 2. Opposite, pinnatisect, with two alternate pairs of lateral segments and a terminal one; all are linear and entire.

No. 3 and all above it. Alternate, pinnatisect; segments linear and entire, or slightly toothed.

No. 4. Pinnatisect; segments alternate and subpinnatifid.

No. 5. Pinnatisect, slightly auricled at the base; segments pinnatifid.

Nos. 6 and 7. Bipinnatisect, auricled at the base with slender laciniæ; primary divisions of leaf oblong-linear in outline; secondary divisions narrow, small, subulate-lanceolate, suddenly pointed.

Nos. 8–10. Pinnatisect with linear, entire, cuspidate segments, channelled on the upper side, as are all the primary divisions of the leaves.

Ursinia anthemoides, *Poir.*

Hypocotyl erect, terete, glabrous, 2–3 cm. long, light green or colourless.

Cotyledons very similar to those of U. speciosa, but subacute; indistinctly one-nerved.

First leaves pinnatisect, with a few scattered hairs; segments linear, acute.

Stem with the primary internodes undeveloped.

Cryptostemma calendulaceum, *R. Br.*

Primary root tapering, flexuose, succulent, colourless, with fibrous lateral rootlets, annual.

Hypocotyl subterranean and with difficulty distinguishable from the root, stout, fleshy, and tapering downwards.

Cotyledons fleshy, oblong, obtuse, tapering into a short petiole, connate and amplexicaul at the base, 1·45 cm. long including petiole, 4 mm. wide above the middle, glabrous.

Stem undeveloped in the seedling stage, and always very short.

Leaves simple, radical, alternate, densely covered on the upper surface with short, jointed, crystalline hairs, woolly on the under surface; petioles flattened above or subchannelled, convex beneath, angled and furrowed, coarsely hairy or becoming woolly.

Nos. 1 and 2. Spathulate, irregularly and obsoletely dentate, tapering to both ends, subacute, with a strong median longitudinal nerve.

No. 3. Oblong, obtuse, repand-dentate, especially at the unsymmetrical base.

Nos. 4 and 5. Oblong, obtuse, lyrate-pinnatifid, unequal at the base; lateral lobes oblong, obtuse or cuspidate; terminal lobe large, oblong, somewhat lobed at the base and toothed upwards.

Ultimate leaves oblanceolate, deeply lyrate-pinnatifid, thinly woolly or subglabrous above, with a hoary tomentum beneath; lower lobes small, oblong, with small teeth; middle lobes broadly oblong in outline with small teeth on the anterior side, and larger on the posterior, and one large oblong, acute, basal lobe; terminal lobe large, broadly triangular, lobulate, coarsely dentate and denticulate.

Venidium calendulaceum, *Less.*

Hypocotyl erect, terete, glabrous, ·5–2 cm. long, light green or colourless.

Cotyledons obovate, obtuse, emarginate, fleshy, slightly petiolate, glabrous, light green, almost colourless in some specimens, indistinctly one-nerved.

Stem short, erect, herbaceous; the primary internodes very slightly developed.

First leaves alternate, cauline, lanceolate, subacute, tapering to the base, scarcely petiolate, thickly pubescent with glandular hairs, entire, slightly ciliated, light green; with a midrib and two lateral nerves running parallel to the edges.

Berkheya purpurea, *Mast.* (fig. 479).

Primary root tapering, giving off a few lateral fibrils.

Hypocotyl short, mostly subterranean, purplish-red, rather succulent.

Cotyledons broadly obovate-oblong, entire, glabrous, 1·05 cm. long, about 9 mm. wide, amplexicaul.

Leaves simple, radical and cauline, alternate, sessile.

Nos. 1 and 2. Elliptical, irregularly spiny-serrulate with small prickles between the larger ones, pilose and bright green above, rather woolly and paler beneath, penninerved.

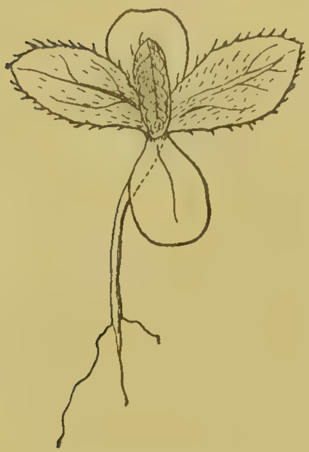

Fig. 479.
Berkheya purpurea.
Nat. size.

Ultimate leaves sessile, linear-oblanceolate, decurrent on the stem, lobulate with the margin undulate and densely spiny, the lobes tipped by a larger spine, covered with coarse jointed hairs above, and woolly or cottony beneath; upper cauline leaves much narrower, linear and somewhat broader above the middle, more deeply lobulate, with somewhat stronger spines.

Gundelia Tournefortii, *L.*

Hypocotyl very stout, buried in the soil or rising from 3–15 mm. above it, emerging from one end of the fruit in germination while the radicle emerges from the other.

Cotyledons oblong, obtuse, entire and rounded at the base, and flat, or variously and unequally emarginate at the apex with a deep longitudinal channel or furrow along the centre or towards one side, and bluntly keeled beneath, fleshy, glabrous, with very difficultly discernible reticulate venation, sessile, connate at the base and forming a long sheath from whence the first leaf emerges while the plumule is still hidden, 2·5–3·2 cm. long, 1–1·5 cm. wide, (sometimes though rarely toothed near the apex). The furrow in the cotyledons is probably due to their being folded longitudinally in the seed.

Leaves simple, radical and cauline, alternate, exstipulate.

First leaf strap-shaped, involute at the base, where it emerges from the sheath of the cotyledons, thickly and unequally serrate with small spiny bristles or teeth; venation incurved and reticulate.

Carduus giganteus, *Desf.*

Hypocotyl very short, erect, terete, glabrous.

Cotyledons long, obovate-oblong, fleshy, obtuse, slightly emarginate, petiolate, glabrous, green, pinnatinerved.

Stem with the primary internodes undeveloped.

Leaves simple, cauline, alternate, petiolate, acute, spiny, hairy, light green, reticulate. The first two are lanceolate-elliptic.

Cnicus diacanthus, *Benth.* (fig. 480).

Primary root a fleshy, colourless taproot, with a few lateral fibres.

Hypocotyl succulent, suberect, terete, 1–2 cm. long, 2 mm. thick, quite glabrous, greenish-white, mostly subterranean.

Cotyledons connate, 2–2·5 cm. long, 1–1·25 cm. wide, obovate or spathulate, produced at the base, rounded at the apex, entire, with distinct midrib, quite glabrous, rather thick, yellowish-green above, paler beneath.

The stem is developed when about to flower.

The first three leaves are 5–8 cm. long, and 1 cm. wide, lanceolate, much narrowed to the base, acute at the apex, with three or more pairs of nerves springing from a broad sunk midrib, and terminating in setaceous teeth, and tomentose, especially on the under side, slightly succulent, bright green above, tomentose beneath.

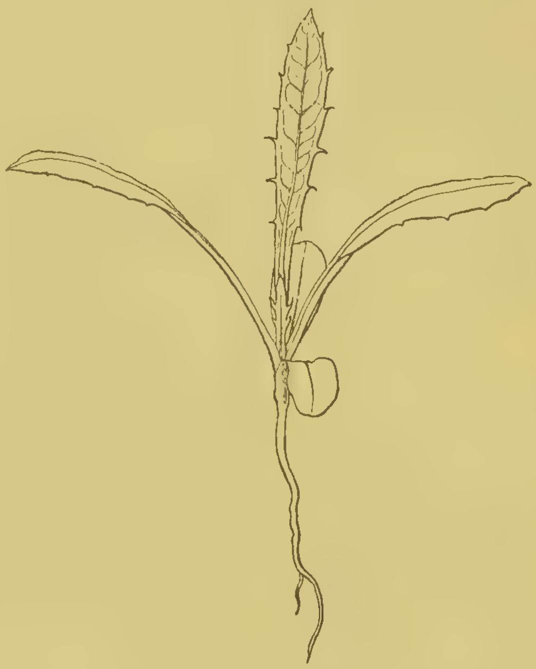

Fig. 480.—*Cnicus diacanthus.* Half nat. size.

Ultimate leaves simple, radical and cauline, alternate, sessile or the radical ones elongated into a petiole-like base, alternately incurvinerved, toothed, or lobed, or subpinnatifid, spiny, deep green above with silvery midrib and principal nerves, somewhat felted or cottony, colourless and tomentose beneath ; radical ones dilated and sheathing at the base.

Cnicus syriacus, *Willd.*

Primary root very long, stout, tapering downwards, with short lateral rootlets, annual.

Hypocotyl very short, and hardly distinguishable from the root.

Cotyledons obovate, obtuse, slightly emarginate or nearly entire, tapering into the broad petiole, which is connate at the base, alternately and ascendingly penninerved, but venation discernible with difficulty, light green above with a purple midrib, much paler beneath, glabrous, 3·5–6·2 cm. long including the petiole, 2–2·5 cm. wide near the apex.

Stem erect, herbaceous, annual, developing when about to flower; primary internodes undeveloped.

Leaves radical and cauline, alternate (first pair opposite), nerves alternately incurving, strongly reticulate, and giving off short more slender branches into the marginal lobes or teeth, margin spiny, subsucculent, thinly hairy on both sides with soft, whitish, jointed hairs, deep green above, with a purple midrib, and marked with broad grey or whitish bands; petioles semiterete with broad shallow channels above which are generally purple with green margins, green beneath, thinly hairy or slightly woolly at the margins, dilated at the base and semi-amplexicaul or those of the first pair connate.

Nos. 1 and 2. Elliptic, obtuse, margin unequally spiny-toothed.

Nos. 3–6. Elliptic or oblong-elliptic, very obtuse, lobulate and spiny-toothed.

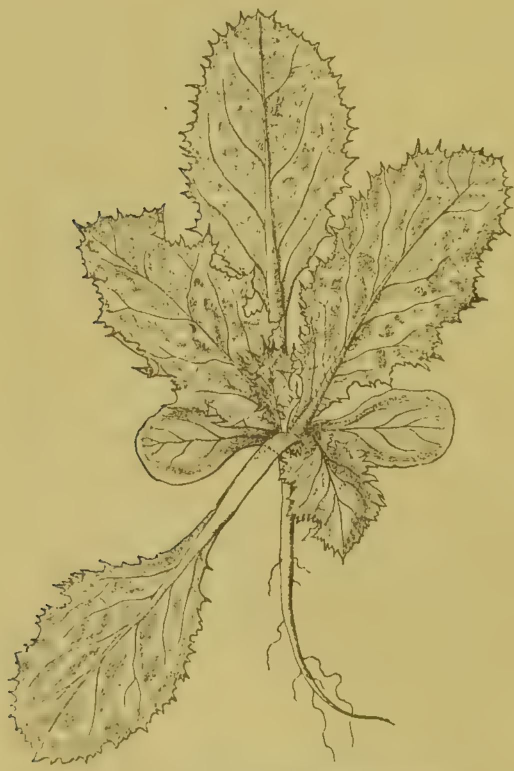
FIG. 481.—*Silybum Marianum.* Half nat. size.

Silybum Marianum, *Gærtn.* (fig. 481).

Primary root long, tapering, fleshy, colourless, giving off lateral fibres, biennial.

Hypocotyl subterranean, stout and scarcely distinguishable from the root.

Cotyledons large, foliaceous, obovate-oblong, obtuse, tapering into the broad, flattened petiole, penninerved, nerves alternate; petiole about 1·7 cm. long, connate and amplexicaul; lamina 2·6 cm. long, 1·8 cm. wide.

Stem developed in the second year.

Leaves radical and cauline, alternate, petiole dilated and sheathing at the base, more or less hairy or villous at the margin and beneath, variegated on the upper surface with ascending and anastomosing, broad, milk-white veins on a bright green ground, paler green on the under side.

Nos. 1 and 2. Oval, obtuse, cuneate at the base, doubly spiny-toothed, sparsely setose on the upper surface, and villous on the midrib beneath.

Nos. 3 and 4. Oblong, obtuse, pinnatifid, cuneate at the base, doubly spiny-toothed. Otherwise like Nos. 1 and 2.

Ultimate leaves oblong-lanceolate, deeply pinnatifid, decurrent on the petiole and auricled at the base, woolly on the midrib and papillose on both surfaces, ultimately glabrous, bright green, reticulated with milky-white veins; lobes broadly deltoid, lobulate, and spiny-serrate, with a large spine terminating each lobe and large tooth.

Tyrimnus leucographus, *Cass.*

Primary root strong, tapering downwards, normal, annual.

Hypocotyl short or hardly developed.

Cotyledons oblong, obtuse, entire, tipped with a pale gland, subfleshy with a strong midrib and indistinctly discernible, alternate, ascending nerves finely but very indistinctly reticulate, tapering at the base into a short broad petiole which is connate with the other one, glabrous, shining on both surfaces, light green above, paler beneath, 1·8–2·2 cm. long including the petiole, 9–10·5 mm. wide.

Stem erect, annual, developed when about to flower, and winged by the decurrent bases of the leaves; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, a few of the primary leaves petiolate, the rest sessile; nerves alternate and incurving, strongly reticulate; thinly hairy on both surfaces, with soft, whitish, jointed hairs, bright green, shining, and irregularly blotched with white markings on the upper surface, uniformly pale green, almost glaucous beneath; petioles of first few leaves very short, flat above, convex on the back, thinly hairy.

Nos. 1 and 2. Oval, obtuse, shortly petiolate, irregularly and minutely spiny-toothed.

Nos. 3–5. Oblong, or oblong-obovate, lobulate, and irregularly spiny-toothed.

Cauline leaves sinuately lobate or pinnatifid, irregularly spiny-toothed, decurrent on the stem, forming wings.

Centaurea Clementei, *Boiss.* (fig. 482).

Primary root pale yellowish, stout or fleshy, tapering, with short stout lateral rootlets.

Hypocotyl stout, glabrous, cylindrical, red above ground and yellowish beneath, 1·3 cm. long, 2·25 mm. thick.

Cotyledons foliaceous, spathulate, obtuse, entire, tapering into the petiole which is dilated and connate with the other one at the base, 3·9 cm. long including the petiole, 1·1 cm. wide near the top, pale green, glabrous.

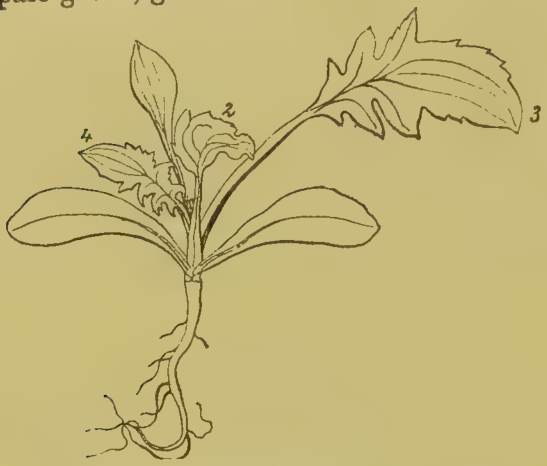

FIG. 482.—*Centaurea Clementei.* Half nat. size.

Stem herbaceous, elongating when about to flower.

Leaves radical and ultimately also cauline, alternate, whitish and cottony on both sides, especially when young; petioles slightly channelled on the upper side, dilated and sheathing at the base.

No. 1. Spathulate, acute, entire.

No. 2. Ovate, subacute, unequally dentate-serrate (deformed in specimen described).

No. 3. Oblong-elliptic in outline, acute, pinnatifid; lower segments small, usually unequal; middle segments larger, ovate, acute, with a strong nerve running into them; terminal segment much the largest, oblong-ovate, trinerved, more or less serrate.

No. 4. Similar but more deeply cut.

Centaurea ragusina, *L.*

Hypocotyl 8–14 mm. long, 1–1·5 mm. thick, pale green, almost wiry in texture.

Cotyledons as in C. Clementei.

Stem herbaceous, very short.

Leaves radical and cauline, alternate, petiolate.

No. 1. Spathulate, obtuse or apiculate, entire, thinly tomentose on both sides, pale green or nearly colourless, thick and soft; petiole 4 mm. long, slightly channelled above.

No. 2. Similar, whiter and more tomentose.

Succeeding forms are gradually larger, spathulate, entire or slightly dentate; then oblong-ovate, obtuse, cuneate at the base, more or less irregularly dentate.

Ultimate leaves oblong, petiolate, lyrate-pinnatifid, felted on both surfaces with a dense white tomentum; terminal segment ovate or triangular-ovate, large, pinnatifid at the base and toothed upwards; lateral segments alternate or subopposite, spathulate-oblong, narrowed to an obtuse point, entire.

Mutisia ilicifolia, *Hook.* (fig. 483).

Hypocotyl extremely short, hardly appearing above the ground, almost square, downy.

Cotyledons ovate, thick, fleshy, acute, recurved, with their points penetrating the ground, glabrous, dark green, indistinctly nerved, with short petioles.

Stem erect, herbaceous, almost square, thickly covered with down; 1st internode very short; 2nd longer.

First leaves simple, cauline, alternate, ovate with a cordate base, toothed or spiny, sessile, clasping the stem, glabrous, light green, with a distinctly reticulate venation. The buds are covered with a thick white down.

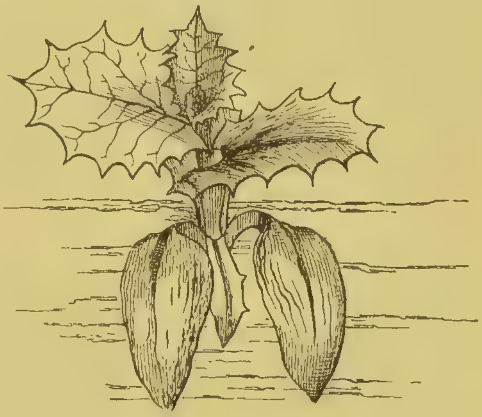

FIG. 483.—*Mutisia ilicifolia.* Half nat. size.

Mutisia copiapina, *Auct.*

Hypocotyl erect, terete, 7·5–10 mm. long, hoary, greenish, or stained with red.

Cotyledons oblong or slightly ovate, large, from 3·5–4 cm. long, ascending, otherwise as in last species.

Stem short, erect, terete, glabrous, light green; 1st internode 1–2 mm. long; 2nd shorter.

Leaves oblong, otherwise as in the last species.

In an abnormal specimen one of the cotyledons was divided down to the base, forming two linear leaves, giving the plant the appearance of having three cotyledons.

Ainsliæa fragrans, *Champ.*

Hypocotyl rather succulent, 5–10 mm. long, 1 mm. thick, terete, glabrous, reddish.

Cotyledons shortly stalked, 1·5 cm. long, 5–7 mm. wide, ovate-oblong, cuneate at the base, with an obtuse apex, entire, glabrous, obscurely nerved and dull greenish-grey above, bronzed beneath, with distinct midrib and two long nerves running just within the margin, thin.

Leaves radical and cauline, alternate, with the principal nerves of the radical leaves radiating from the base of the blade and incurved, hairy; cauline small; petiole semiterete, hairy.

Nos. 1 and 2. Roundly cordate, cuspidate or mucronate, pubescent and hispid, with bristly upcurved teeth at the margin and a pubescent petiole.

Gerbera lanuginosa, *Benth.* (fig. 484).

Primary root normal, tapering, flexuose, branching.

Hypocotyl short, colourless, succulent, 2 mm. long.

Cotyledons oblong, obtuse, 8–10 mm. long, 4 mm. wide; petiole channelled above, convex beneath, 7 mm. long.

Leaves simple, radical, alternate, glabrous above and felted with white tomentum beneath, decurrent on the petiole; petioles dilated and sheathing at the base, deeply channelled above, glabrous, except where the lamina is decurrent, woolly in the adult.

No. 1. Roundish-rhomboid, cuneate at the base, subrepand-denticulate, teeth almost reduced to mucros.

No. 2. Rotund-cordate, acute, repand-denticulate, with mucronate teeth.

Ultimate leaves lyrate-pinnatifid, oblong-obovate in outline, petiolate, glabrescent above, felted beneath with white tomentum; lateral lobes alternate, short, rounded, becoming very much smaller towards the base; terminal one much the largest, oblong, obtuse, distantly and mucronately dentate, frequently truncate at the base, very short and broad; petioles channelled above, woolly.

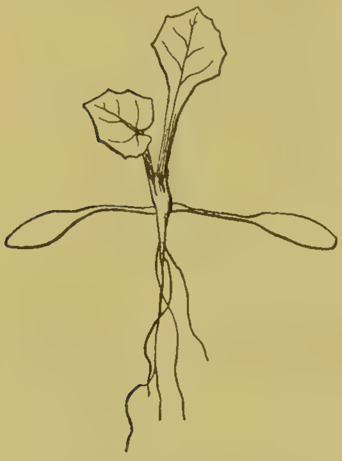
FIG. 484.
Gerbera lanuginosa.
Nat. size.

Leuceria senecioides, *Hook. et Arn.*

Hypocotyl erect, terete, finely pubescent, 1–1·5 mm. long, light green or colourless.

Cotyledons subrotund, emarginate, obtuse, fleshy, petiolate, green, very indistinctly pinnatinerved; petioles and margin with a few short hairs, otherwise glabrous.

Stem with the primary internodes undeveloped.

First leaves simple, cauline, alternate, sinuate, subacute, obovate-oblong, petiolate, finely pubescent, light green, pinnatinerved, with alternate or subopposite, obtuse or acute lobes.

Moscharia pinnatifida, *Ruiz et Pav.* (fig. 485).

Achene enclosed in an oblique or subcarinate bract, which springs from the receptacle and entirely surrounds it; obovate, suboblique, with a short pappus of feathery unequal hairs springing apparently from one corner and fitting into the cavity of the receptacular bract.

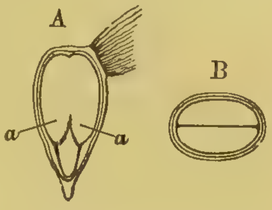

Fig. 485.—*Moscharia pinnatifida.* A, longitudinal section of achene, showing embryo, × 8. B, transverse section of achene, × 8.

Seed obovoid, obtuse at both ends, brown, smooth, small; hilum basal; chalaza apical.

Endosperm absent.

Embryo obovoid, fleshy, colourless, filling the cavity of the seed, straight; cotyledons plano-convex, closely applied face to face, minutely emarginate; radicle subturbinate, stout, obtuse, short, close to the hilum.

Moscharia rosea, *Ruiz et Pav.* (fig. 486).

Primary root vertical, slender, colourless, with a few fibres.

Hypocotyl succulent, about 1 cm. long, 1·5 mm. thick, terete, pubescent, colourless.

Cotyledons oblate, 6 mm. long, 8 mm. wide, retuse or emarginate at the apex, obscurely nerved, pubescent, thin, yellowish-green; petioles about 8 mm. long, 1·5 mm. wide, connate, pubescent.

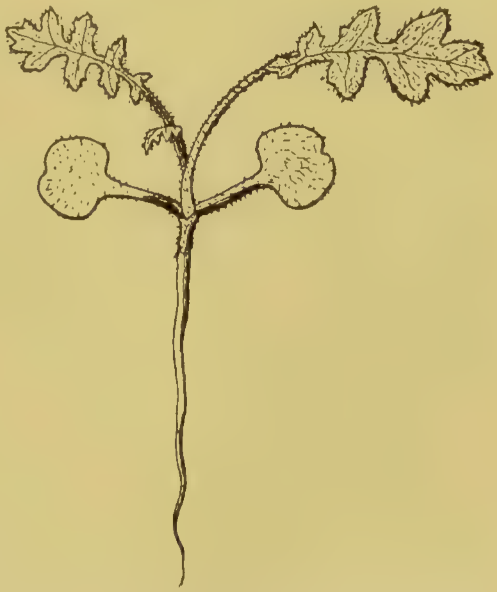

Fig. 486.—*Moscharia rosea.* Nat. size.

Stem short, succulent, pubescent and reddish when quite young.

The first leaf is lyrately pinnatifid, penninerved, pubescent, thin, including the long pubescent petiole about 3 cm. long, nearly 1 cm. wide, yellowish-green. The next two are similar.

Ultimate leaves simple, radical, and cauline, alternate, petiolate or sessile, alternately penninerved, pinnatifid, hairy; petiole of the radical leaves semiterete, hairy, dilated and sheathing at the base.

Microseris Bigelovii, *A. Gray.*

Primary root annual, tapering, slender and branched.

Hypocotyl glabrous, terete, red, 9–12 mm. long, tapering into and hardly distinguishable from the root.

Cotyledons linear, slender.

Stem herbaceous, annual, erect, terete, thinly glandular-hairy, reddish or purplish; 1st internode ·5–1 mm. long; 2nd about 1 mm.

Leaves simple, cauline, alternate, sessile, sheathing at the base, and ciliate there with white hairs, especially on the sheathing part.

Nos. 1–6. Linear, entire, acute, shallowly channelled above, slightly keeled beneath, and very slightly widened above the middle, so that they do not greatly differ from the cotyledons.

Rhagadiolus stellatus, *DC.*

Achene almost enclosed by a partially lignified bract; lanceolate or subulate, straight or curved, prolonged into a beak, or in others crowned by a pappus.

Seed conforming in shape to the fruit, somewhat laterally flattened or terete; testa smooth; hilum inconspicuous.

Embryo straight, filling the whole of the seed; cotyledons linear, obtuse, entire, yellowish-white, plano-convex, closely adpressed face to face, sessile, lying the broad way of the seed, with their edges to the axis of the disc; radicle short, terete, much shorter than the cotyledons, obtuse.

Seedling (fig. 487).

Primary root long, slender, tapering, giving off numerous lateral rootlets, annual.

Hypocotyl short, stout, fleshy, passing into the root.

Cotyledons oblong-spathulate, obtuse, glabrous, 1·5 cm. long; petiole flattened above, scarcely channelled, 1 cm. long.

Stem annual, developed when about to flower.

Leaves simple, radical, ultimately cauline, alternate, light green, rather coarsely hairy, especially on the under side and the petioles;

petioles short or none, winged for a great part by the decurrent lamina, flattened above, dilated at the base.

No. 1. With a short, broadly elliptic lamina, decurrent nearly to the base of the petiole, obsoletely, distantly, and mucronately dentate.

No. 2. With a rotund lamina decurrent on the petiole; wing with a few deltoid mucronate teeth.

Nos. 3–6. Irregularly runcinate; terminal segment rotund, obsoletely, mucronately dentate; lateral segments of Nos. 3 and 4 deltoid, mucronate, decurved; lateral segments of Nos. 5 and 6 broadly oblong, mucronate, obtuse, subdecurved.

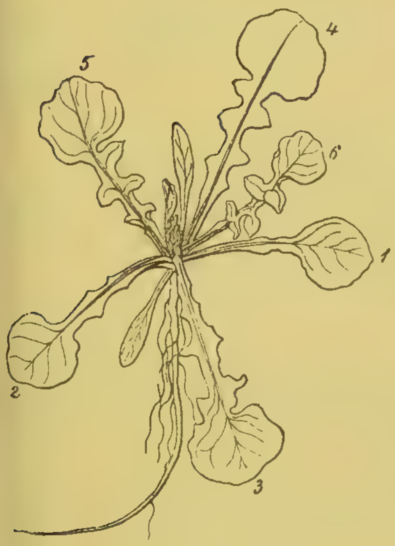

Fig. 487.—*Rhagadiolus stellatus.* Half nat. size.

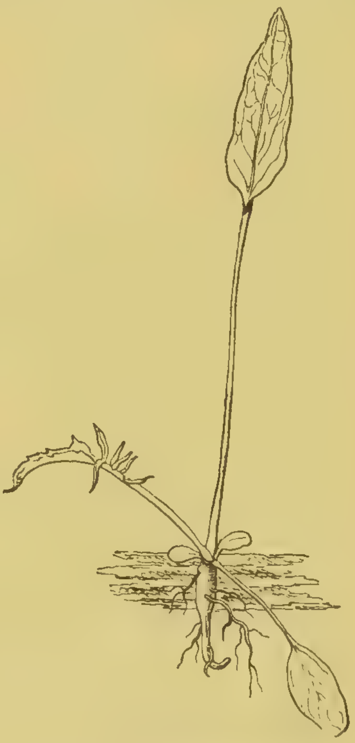

Fig. 488.—*Lactuca lævigata.* Half nat. size.

Lactuca lævigata, *DC.* (fig. 488).

Primary root a short, stout, fleshy or tuberous taproot, colourless, giving off numerous lateral branching fibres.

Hypocotyl subterranean.

Cotyledons spathulate, obtuse, entire, glabrous, 8 to 10 mm. long.

Leaves radical, alternate, glabrous, with petioles sheathing at the base.

No. 1. Oval, obtuse, entire, cuneate at the base, obscurely penninerved and reticulate, pale green above, glaucous beneath; petiole terete, slender, pale green mottled with purple, sheathing at the base.

No. 2. Lanceolate, obtuse, entire, five-nerved and reticulate, deep green above, glaucous beneath; petiole terete, pale green, closely mottled and streaked with purple, sheathing at the base.

No. 3. Lyrate-pinnatifid of seven segments; segments linear, obtuse or subacute, glaucous-green suffused with purple, the lowest pair smallest; terminal segment much the largest, oblong-lanceolate, obtuse, irregularly serrate, penninerved and reticulate, glaucous-green suffused with purple, glaucous beneath; petiole terete, pale green mottled and streaked with purple.

Sonchus squarrosus, *DC.*

Hypocotyl erect, terete, glabrous, 1–1·5 mm. long, light green or colourless.

Cotyledons oblong-obovate, obtuse, emarginate, petiolate, glabrous, light green, pinnatinerved like the leaves.

Stem herbaceous, erect; primary internodes undeveloped.

Primary leaves simple, alternate, subrotund, obtuse, dentate-serrate, with a few scattered bristly hairs above, glabrous beneath, light green with a faint tinge of violet, pinnatinerved.

Sonchus arvensis, *L.*

Leaves simple, ultimately more or less pinnatifid and spiny-toothed, thinly glandular-hairy or pubescent on both surfaces, at least in the seedling stage.

No. 1. Obovate-spathulate, entire, 1·7 cm. long.

Nos. 2 and 3. Oblanceolate-spathulate, irregularly spiny-denticulate.

No. 4. Spathulate, subdecurrent on the petiole, with margin undulate, spiny-toothed.

No. 5. Spathulate-oblong, margin undulate, spiny-toothed.

No. 6. Linear-oblong, sessile, broadest near the tip, tapering to the base, irregularly doubly spiny-toothed.

No. 7. Linear-oblong, lobulate and spiny-toothed, margin undulate, sessile, tapering to the base.

Nos. 8 and 9. Linear-oblong, subpinnatifid with undulate, spiny-toothed lobes.

Zollikoferia sp.

Hypocotyl erect, terete, glabrous, 6–10 mm. long, light green or colourless.

Cotyledons spathulate-obovate, obtuse, slightly emarginate, glabrous, light green, indistinctly trinerved.

Stem with the primary internodes undeveloped.

First leaves simple, cauline, alternate, or in some plants the first pair are opposite, dentate, oblong-obovate, obtuse, petiolate, glabrous, light green, reticulate.

Tragopogon crocifolium, *L.*

Hypocotyl erect, terete, glabrous, 8–10 mm. long, tinged with red.

Cotyledons long, linear, acute, clasping the stem, sessile, glabrous, light green, one-nerved like the first leaves.

Stem with primary internodes undeveloped.

First leaves simple, entire, radical, alternate, linear, narrow, acute, light green, glabrous, one-nerved.

STYLIDIEÆ.

Benth. et Hook. *Gen. Pl.* ii. 534.

Fruit and Seed.—The ovary is inferior and two-celled, or one-celled at the very base. The ovules are very numerous in each cell, attached to the middle of the axile placentas and anatropous. The fruit is capsular and two-celled, or one-celled by the disappearance of the dissepiment, generally dehiscing by two valves parallel to the septum, more rarely indehiscent. The seeds are numerous, rarely solitary by abortion, and always small with a membranous testa and a fleshy endosperm. The embryo is minute, embedded in the endosperm, with the radicle close to the hilum.

The species of Levenhookia have generally a one-celled ovary with a few seeds arising from a basal placenta and more or less attached to the side walls.

Seedlings.—This Order is a small one, containing about one hundred species or slightly fewer, of which the typical genus Stylidium numbers about eighty-four, of various habit but always herbaceous, and often with small densely arranged leaves somewhat resembling a Heath. S. adnatum (fig. 489) is the only species observed. The cotyledons are small, obovate, minutely cuspidate, sessile, tapering to the base and slightly connate. The leaves are somewhat similar, but narrower and densely arranged.

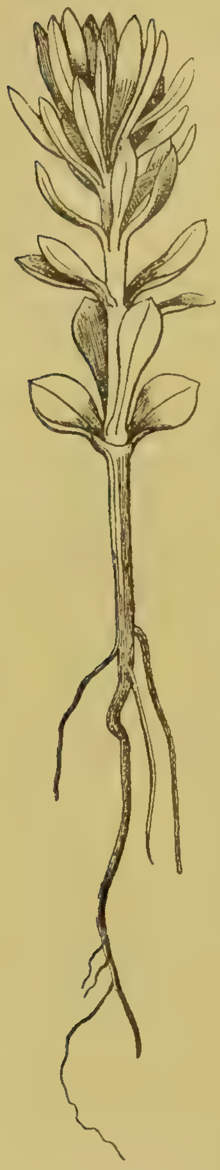

FIG. 489. *Stylidium adnatum*, × 8.

Stylidium adnatum, *R. Br.* (fig. 489).

Primary root tapering downwards, flexuose, slender, with slender lateral rootlets, perennial.

Hypocotyl erect, terete, more or less rough, with little tuberculated elevations, pale flesh-coloured or colourless, 6·5–11 mm. long.

Cotyledons obovate, obtuse, indistinctly petiolate, entire, minutely cuspidate, glabrous, light green, with a difficultly discernible midrib, 2·75–3·5 mm. long including the petiole-like base, 1·75–2 mm. wide.

Stem erect, subterete or obtusely angled, glabrous, but roughened with numerous small colourless elevations, leafy; 1st and 2nd internodes undeveloped; 3rd very variable, 2–6 mm. long; the rest generally very short with the leaves close together.

Leaves simple, entire, cauline, alternate (the first two opposite, decussating with the cotyledons), exstipulate, petiolate, with a midrib, but no other discernible venation in the fresh state, scaberulous or minutely ciliate at the margin with colourless hairs or short points, otherwise glabrous, light green; petiole biconvex, narrowly channelled above, thickened at its insertion on the stem, short, glabrous, pale green.

Nos. 1–30. All similar, small, spathulate or oblanceolate, minutely cuspidate, narrowed into the petiole, very numerous and closely aggregated.

CAMPANULACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 541.

Fruit and Seed.—The ovary is inferior or half, rarely wholly superior, and generally 2–5-, rarely 6–10-celled, and consisting of as many carpels; a one-celled condition is rare and then probably occurs through the abortion of one out of two carpels, or more generally by the disappearance of the septa during growth. The placentas are mostly axile, sometimes attached to the middle of the septa where they become stalked or peltate. The ovules are numerous, rarely two, and attached either at the top or base of the cell, erect, horizontal, or pendulous and anatropous. The fruit is capsular or baccate, dehiscing variously by pores or valves beneath or above the calyx-limb, or indehiscent and liberating the seeds by decay. The seeds are mostly very small and numerous with a membranous or leathery testa. The embryo is also minute and embedded in the axis of the endosperm with the radicle close to the hilum.

Exceptions occur in species of Lysipoma, Clermontia and Delissea, which have a one-celled ovary with parietal placentas, but even here these conditions are very rare. In Merciera the one-celled ovary has a pair of basal erect ovules; and in Siphocodon the ovary is three-celled, but the ovules are suspended from the apex of the cavities. Baccate fruits occur in Pratia, Colensoa, Rollandia, Cyanea, Delissea, Clermontia, and others both of the tribes Lobelieæ and Campanuleæ.

Seedlings.—Amongst the seedlings observed are three different types of cotyledons, namely, subulate, ovate, and rotund or suborbicular, frequently emarginate. As the embryo is very small while yet in the seed, the ultimate form of the cotyledons is due to growth or development during and after germination.

The subulate type may be represented by Downingia pulchella (fig. 490). The cotyledons are subulate-linear, 6–7 mm. long, and precisely similar to the first pair of leaves. The upper leaves become gradually wider and 3–5-nerved. The ovate type is fairly represented by Lobelia Erinus (fig. 492).

Although very small they are mostly if not always slightly emarginate and shortly petiolate, not only in this species but the whole group. The first two leaves of L. Erinus are ovate or elliptic with slender petioles. The cotyledons of Lobelia tenuior are much larger, ovate, and emarginate with longer petioles. The first two leaves are rhomboid, while the third is shallowly five-lobed.

Another type is furnished by Campanula bononiensis (fig. 493). The cotyledons resemble those of Lobelia tenuior. The first leaf is spathulate-ovate, the second oval, and the third and fourth obovate. The cotyledons of C. thyrsoides are smaller, and the first leaf is also relatively small, ovate, and obscurely dentate. Succeeding leaves vary through ovate, oval, obovate and elliptic forms, at the same time greatly increasing in size, and much exceeding in that respect any of the above mentioned.

Suborbicular and emarginate cotyledons are met with in Campanula gummifera. They are also more markedly reticulate than is generally the case. The first leaf is cordate, crenate, and hairy. The cotyledons of Specularia castellana are emarginate and rather broader than long. Three or four of the primary leaves are suborbicular, shallowly crenate and hairy. The seedling of Colensoa physaloides (fig. 491) recalls that of Campanula thyrsoides to some extent in its small entire cotyledons and the graduation of the leaves from the first small one to the fifth, and onwards. The internodes are, however, much more elongated. A slightly different type occurs in Specularia biflora which has comparatively large oblong-obovate emarginate cotyledons tapering into a long petiole.

The first four leaves are obovate-spathulate, and obscurely crenate, with glands in the notches, not on the crenatures.

Downingia pulchella, *Torr.* (fig. 490).

Primary root slender, colourless, soon giving rise to a fascicle of strong colourless roots from its base.

Hypocotyl herbaceous, strong, erect, terete, glabrous, 1·5–2·2 cm. long and 1 mm. thick, or more.

Cotyledons subulate-linear, slender, acute, deep green and shining, 6–7 mm. long, precisely similar to the first four pairs of leaves.

Stem herbaceous, erect, stout, glabrous, green; internodes short; 1st 4–5 mm. long; 2nd 2·5–3 mm.

Leaves simple, entire, cauline, alternate (lower opposite), exstipulate, glabrous, slender at least in the young plant.

Nos. 1–8 or 10. In decussate pairs, linear-subulate, acuminate, and showing a midrib only.

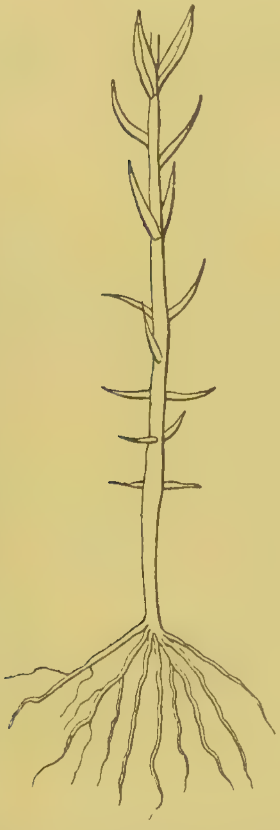

Fig. 490.—*Downingia pulchella.* Nat. size.

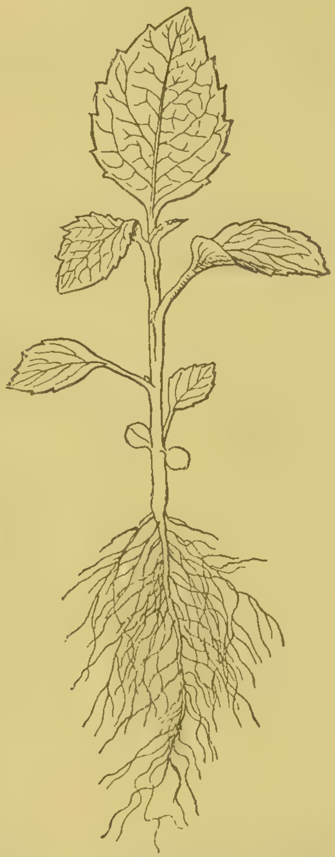

Fig. 491.—*Colensoa physaloides.* Nat. size.

Above this they are gradually broader, and three- to five-nerved from the base.

Colensoa physaloides, *Hook. f.* (fig. 491).

Primary root densely fibrous.

Hypocotyl 5 mm. long, 1·5 mm. thick, terete, herbaceous, glabrous, usually purplish-green.

Cotyledons 4–5 mm. long, 2·5–3 mm. wide, broadly petiolate, suborbicular, entire, glabrous, very obscurely nerved, dark dull green above, paler beneath.

Stem.—1st internode 1–2 mm. long, and as thick; 2nd–4th about 5 mm. long, ridged owing to the decurrent petioles of the leaves.

Leaves.—No. 1. About 1 cm. long including petiole, 5 mm. wide, elliptic, oblique, acute, slightly serrate, penninerved, glabrous except a few hairs on lower side of the petiole and midrib, thin, slender, dull green.

Nos. 2–5. More deeply mucronate-serrate.

Ultimate leaves simple, cauline, alternate, exstipulate, petiolate, alternately incurvinerved, reticulate, glabrous or nearly so, simply or doubly serrate.

Lobelia Erinus, *L.* (fig. 492).

Primary root fibrous, slender, colourless.

Hypocotyl 5 mm. long, 1 mm. thick, terete, slender, colourless.

Cotyledons 4 mm. long including the short petiole, 2·5 mm. wide, ovate, slightly emarginate, cuneate at base, glabrous and very obscurely nerved, light green.

Stem.—1st internode 5 mm. long, 1 mm. thick; 2nd 1·5–2 cm. long, slender, terete, glabrous, almost colourless.

The two first leaves are like the cotyledons but larger; petiole, 1·5–2 cm. long, ·75 mm. wide, glabrous; blade 1 cm. long, nearly as wide, entire.

The second is often serrate-crenate near the base, penninerved, with a few hairs on the petiole.

Ultimate leaves simple, cauline, alternately penninerved, glabrous or slightly hairy on the petiole, thin, membranous, with milky juice, deep green; petiole slender, rather brittle.

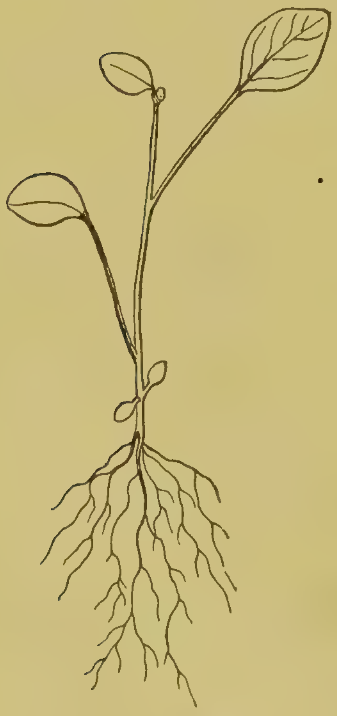

Fig. 492.—*Lobelia Erinus.* Nat. size.

Lobelia tenuior, *R. Br.*

Primary root as in L. Erinus.

Hypocotyl erect, terete, glabrous, purple above ground, colourless beneath, 2–2·6 cm. long.

Cotyledons ovate, obtuse, emarginate, glabrous, stained with purple; lamina 3–3·5 mm. long, 2–3 mm. wide, with indistinct venation; petiole slightly flattened above, the two sometimes slightly alternate, 2·5–4 mm. long.

Stem herbaceous, erect, at least in the seedling stage, terete, striated, glabrous with the exception of some lines of hairs running down from the decurrent bases of the leaves, stained with purple; 1st internode 3–4 mm. long; 2nd 2–3 mm.

Leaves glabrous, with ascending nerves running into the teeth or lobes; petiole flattened or slightly channelled above, rough on the back and margin.

No. 1. Rhomboid, obtuse, obsoletely dentate at the margin.

No. 2. Larger, similar, but with five blunt teeth.

No. 3. Shallowly five-lobed.

Campanula bononiensis, *L.* (fig. 493).

Primary root vertical, small, slender, colourless, with a few fibres.

Hypocotyl 2–2·5 cm. long, ·7 mm. thick, terete, glabrous, nearly colourless.

Cotyledons nearly equal, about 7 mm. long, 3–4 mm. wide, shortly stalked, ovate, cuneate at the base, obtusely emarginate, obscurely nerved, entire, glabrous, light green.

Stem herbaceous, erect, terete, hairy; 1st internode 3·5 mm. long.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, hairy on both sides, but chiefly on the margins and the nerves beneath; petioles channelled above, convex beneath, dilated and amplexicaul at the base, coarsely hairy.

No. 1. Spathulate-obovate, entire.

No. 2. Oval, obtuse, tapering to the base, obsoletely crenate-serrate.

Nos. 3 and 4. Obovate, obtuse, serrate-crenate, subreticulately veined.

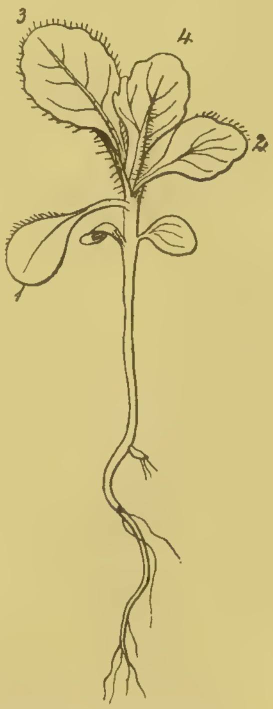

Fig. 493.
Campanula bononiensis.
Nat. size.

Campanula gummifera, *Willd.*

Hypocotyl glabrous, 6–10 mm. long, light green or colourless.

Cotyledons ovate-rotund, slightly emarginate, obtuse, petiolate, glabrous, light green, indistinctly pinnatinerved like the leaves.

Stem with primary internodes undeveloped.

First leaves simple, radical, alternate, cordate, crenate-serrate, hairy with rather long stiff hairs, green, pinnatinerved; petiole long, furrowed above.

Campanula thyrsoides, *L.*

Primary root tapering, twisted or flexuose near the top, and giving off numerous lateral fibres, biennial.

Hypocotyl subterranean, short, stout, fleshy, colourless, glabrous, 5 mm. long.

Cotyledons small, ovate, obtuse, subpetiolate, 3·5 mm. long, 2·5 mm. wide, hairy.

Stem herbaceous, developed when about to flower.

Leaves radical and cauline, sessile (or the first two to four shortly petiolate), light green and shining above, paler and shining beneath, densely hairy on both surfaces, penninerved with alternate nerves; petioles of first four leaves, short, broad, flattened above.

No. 1. Ovate, obtuse, slightly dentate, 7·5 mm. long, 5 mm. wide.

No. 2. Similar, larger.

No. 3. Oval, obtuse, serrulate, cuneate at the base.

No. 4. Ovate, obtuse, cuneate at the base, serrulate.

No. 5. Elliptic, obtuse, serrulate, cuneate at the base and sessile.

No. 6. Oblong-elliptic, obtuse, serrulate, cuneate at the base, sessile.

No. 7. Obovate, obtuse, crenate-serrate.

Nos. 8 and 9. Oblong-elliptic, obtuse, crenate-serrate.

Ultimate leaves obovate-spathulate, subacute, tapering to the base, mucronately serrulate, bright green, shining and hairy above especially towards the margin, paler beneath, shining and nearly glabrous, flat or concave.

Specularia castellana, *Lge.*

Hypocotyl erect, terete, glabrous, 1·4–1·8 cm. long, light green, or colourless.

Cotyledons ovate-rotund, small, emarginate, glabrous, green, indistinctly one-nerved; petioles rather broad, very slightly channelled on the upper face.

Stem with primary internodes undeveloped.

Primary leaves broadly oblong or subrotund, radical, alternate, obtuse, crenate, finely pubescent, green, pinnatinerved; with broad hairy petioles, channelled above.

Specularia biflora, *A. Gray.*

Primary root long, with short lateral fibres.

Hypocotyl 2–2·5 cm. long.

Cotyledons oblong-obovate, 5–6·5 mm. long, 4–4·5 mm. wide; tapering into the long petiole, which is slightly channelled above, 9–11 mm. long.

Stem erect, terete, striate, pubescent, herbaceous, twisted; 1st internode 1 cm. long; 2nd longer.

Leaves thinly pubescent, tapering into and slightly decurrent on the petiole which is channelled above, venation reticulate but very indistinct.

Nos. 1–4. Obovate-spathulate, obtuse, obsoletely crenate, with glands in the notches, and in the apical one when the leaf is emarginate.

ERICACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 577.

Fruit and Seed.—The ovary is superior and consists of two to twelve carpels united so as to form as many cells; the union may be complete or the carpels may be partly free at the top, making the ovary lobed as occurs in many of the Rutaceæ and Labiatæ. The ovules are numerous and inserted on axile placentas, or suspended from the apex of the cells and anatropous; they rarely ascend from the base of the cells. The fruit is capsular, rarely baccate as in Arbutus and Pernettya or drupaceous as in Arctostaphylos, and dehisces loculicidally or septicidally by as many valves as there are carpels, or the carpels may break away from the axial placentiferous column. Fruits breaking up into cocci are very rare. The seeds vary from one to many, but they are usually minute and very numerous, angled or compressed, with a closely fitting or sometimes a loose testa prolonged at either end. The embryo is embedded in a fleshy endosperm, with short cotyledons and a rather elongated radicle.

Seedlings.—The seeds are minute in most cases, and the cotyledons generally small. The seedlings of Rhododendron arboreum (fig. 494) and Erica Tetralix represent therefore the more typical forms of the Order. The cotyledons of Rhododendron arboreum are small, oval and pubescent. The two primary leaves are also oval, but several times larger. The ultimate ones are oblong-lanceolate, entire, and attain a length of six to nine inches. The genus Erica is represented by E. Tetralix which has minute oval cotyledons, and always very small leaves. In a seedling observed the first pair of leaves were opposite, followed by four whorls of three each, above which were a few scattered ones, those again followed by whorls of four leaves each as in the adult plant. In the seedling they are flat, in the adult strongly revolute at the margins.

A curious type occurs in Enkianthus japonicus, the cotyledons of which are oblong-ovate and crenulate, as in Ptelea trifoliata amongst the Rutaceæ. The first four leaves are elliptic and serrulate. Another unusual form occurs in Clethra arborea which has relatively large and broadly oblong-ovate, slightly emarginate cotyledons. They are finely pubescent, as are the first pair of coarsely serrated leaves.

Enkianthus japonicus, *Hook.*

Hypocotyl erect, terete, pale green, ultimately glabrous, 8·5 mm. above the soil.

Cotyledons oblong-ovate, obtuse, minutely mucronate, alternately penninerved, shallowly crenate, glabrous, shining on both surfaces, bright green above, paler beneath; lamina 8·5 mm. long, 5 mm. wide; petiole flattened above, 1 mm. long.

Stem woody, erect, terete, with short decurrent wings from the base and under side of the petioles, pubescent; 1st and 2nd internodes undeveloped; 3rd ·5 mm.; 4th 2·5 mm.; 5th 3 mm.; 6th 2·25 mm.; 7th 3 mm.; 8th 1·5 mm.; 9th 1·75 mm.; 10th 1 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, ciliate-serrulate, pubescent above, hairs with short fleshy bases and hooked tips, ultimately glabrous or pubescent on the midrib, paler beneath and pubescent on the principal nerves only, and slightly woolly near the base, alternately penninerved with ascending subincurved nerves; petioles deeply channelled above, subcarinate, pubescent with hairs on the margins and carina like those of the lamina.

Nos. 1–4. Elliptic, acute, serrulate or ciliate-serrulate.

Nos. 5–19. Lanceolate-elliptic, acute, ciliate-serrulate.

Ultimate leaves obovate, apiculate, tapering much to the base, ciliate-serrulate with the hairs hooked forwards as in the cotyledons.

Erica Tetralix, *L.*

Hypocotyl erect, terete, filiform, glabrous, reddish, 3 mm. long.

Cotyledons minute, oval, obtuse, glabrous ; lamina 1·25 mm. long, 1 mm. wide ; petiole ·5 mm. long.

Stem erect, filiform, ultimately woody, finely pubescent ; 1st internode undeveloped ; 2nd 3·5 mm. long ; 3rd 4·5 mm. ; 4th 4 mm. ; 5th 3 mm. ; 6th 3 mm. The plant was raised in heat ; probably the internodes would be much shorter if raised in the open air.

Leaves entire, verticillate, shortly petiolate, glabrous in the seedling stage and frequently aristate, ciliate on the lateral nerves in the adult plant, not on the revolute margins, flat in the seedling stage and strongly revolute at the margins in the adult plant, deep green above, glaucous beneath, convex above in the adult, concave beneath ; petioles about 1 mm. long, channelled above, ciliate at the margins.

First pair of leaves opposite, obtuse.

Second to fifth nodes with the leaves verticillate in threes, and ovate, subacute.

Then in the seedling noted, five scattered, ovate, aristate leaves occurred ; then two nodes each with four verticillate leaves.

Ultimate leaves verticillate with four in a whorl, oblong - ovate, obtuse, trinerved, ciliate on the lateral nerves and strongly revolute at the edges.

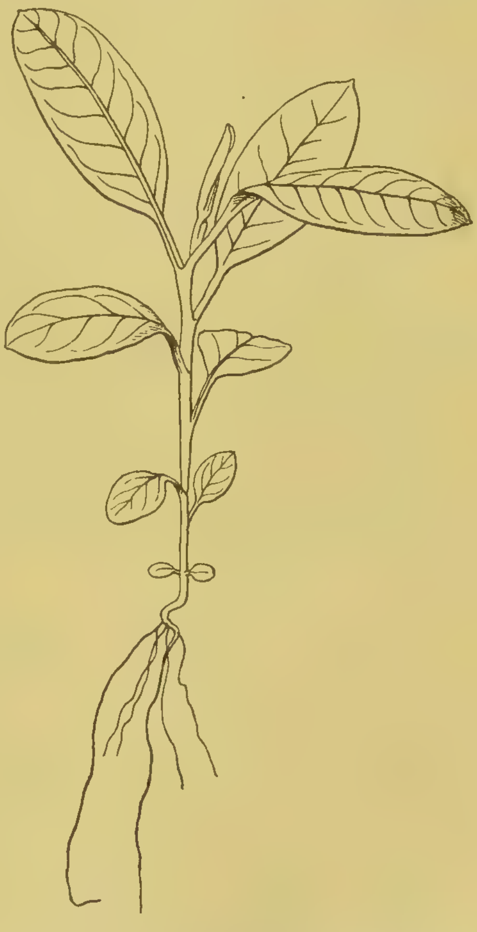

FIG. 494.—*Rhododendron arboreum.* Nat. size.

Rhododendron arboreum, *Sm.* (fig. 494).

Primary root slender, wiry, with numerous lateral rootlets, flexuose.

Hypocotyl short, erect, terete, glabrous, about 3 mm. long.

Cotyledons small, oval, obtuse, pubescent above, 3 mm. long including the short petiole, 2 mm. wide.

Stem woody, erect, terete, glandular-pubescent, reddish; 1st internode 3·5 mm. long; 2nd 2·5 mm.; 3rd 5 mm.; 4th 3 mm.; 5th 5·5 mm.; 6th 3·25 mm.

Leaves alternate, evergreen, pubescent above and on the principal nerves beneath, glandular-ciliate, revolute at the margin in vernation, alternately penninerved; petioles channelled above, reddish and pubescent with rufous hairs.

No. 1. Oval, mucronate; lamina 6·5 mm. long, 4·5 mm. wide.

Nos. 2 and 3. Broadly oval, obtuse, mucronate.

Nos. 4–7. Oblong, obtuse, mucronate.

Ultimate leaves oblong-lanceolate, acute, entire, tapering to both ends, slightly revolute at the margin, and somewhat channelled, thinly scurfy and deep green above, densely felted with white or sometimes rusty scales beneath, with a prominent midrib.

Clethra arborea, *Ait.*

Hypocotyl covered with minute hairs, 1·5–2·5 cm. long, light green.

Cotyledons broadly oblong-ovate, obtuse, slightly emarginate, entire at first, minutely pubescent above, glabrous beneath, green, pinnatinerved like the leaves; petioles rather short and flat, shallowly channelled on the upper side, minutely pubescent.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 4–5 mm. long.

First leaves opposite, decussate, oblong, acute, coarsely serrate, pubescent, green, pinnatinerved, with short petioles.

PLUMBAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 623.

Fruit and Seed.—The syncarpous ovary is superior, and consists of five carpels cohering to form one cell. The ovule is solitary, anatropous, and suspended from a long slender funicle arising from a basal placenta, so that the micropyle is superior. The fruit is dry and included in the persistent calyx, more rarely elongated and somewhat protruding. It is indehiscent, or in some cases the hardened apex falls away like an operculum leaving the cavity open, or the pericarp is circumscissile near the base, while the portion that falls away is more or less divided into five valves. The seed fills the cavity of the ovary to which it conforms, and is suspended by a long funicle to which it is sometimes adnate, and its testa is membranous. The endosperm is copious, or scanty and farinaceous, or altogether wanting. Where it is present the embryo is straight, axile, and almost equals it in length; but where there is no endosperm the terete or slightly compressed embryo fills the seed. The cotyledons are linear or oblong and equal to or larger than the terete radicle.

In Plumbago the cotyledons are much wider than the radicle, and the endosperm is generally scanty. The seeds of Ægialitis are linear, exalbuminous and conform to the fruit. The cotyledons of Armeria grandiflora are linear-oblong and surrounded by a small quantity of endosperm. The radicle is very short.

Seedlings.—Two moderately distinct types of cotyledons were observed, namely, spathulate and linear; but the two are connected by intermediate forms. The tendency to elongation is due to the form of the seed, and that again conforms to the narrow and elongated character of the fruit. Both fruit and seeds vary in width in different species, and so do the cotyledons both before and after germination.

The cotyledons of Statice speciosa (fig. 495) are spathulate, obtuse and entire. The first four leaves are also spathulate, more acute, and much larger, and the ultimate ones hardly differ except in their much greater size. The cotyledons of S. macrophylla flabellata differ in being obtuse and slightly emarginate. The first two leaves are rotund and cuneate at the base, followed by three others which are obovate. Intermediate forms between these and the linear type are furnished by Armeria chilensis and Statice Suworowi (fig. 496). The cotyledons of the former are linear-spathulate and wider than the first pair of leaves. Those of the latter are smaller and narrower than the first leaf which is spathulate-linear. The second and third leaves are also spathulate and larger, while succeeding ones are scalloped or repandly pinnatifid. The cotyledons of Statice leptostachya are long and narrowly linear, while all the leaves are pinnatisect with linear segments.

Statice speciosa, *L.* (fig. 495).

Primary root slender, tapering, with a few lateral rootlets.

Hypocotyl usually subterranean, tapering downwards, 4 mm. long.

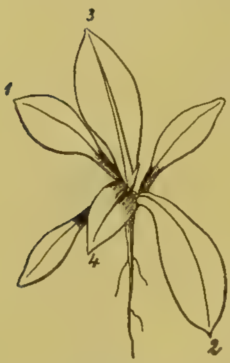

FIG. 495.
Statice speciosa.
Nat. size.

Cotyledons spathulate, obtuse, glabrous, fleshy, dotted on the upper surface with a white excretion, otherwise deep green, 1·25 cm. long including the petiole, 4 mm. wide about the middle of the lamina.

Stem very short.

Leaves simple, entire, radical, alternate, exstipulate, sessile, glabrous, opaque, coriaceous, glaucous-green above, and closely dotted with a white excretion, much paler beneath, tapering gradually to the base, forming a broad-winged petiole-like stalk, shallowly grooved above, dilated and sheathing at the base.

No. 1. Spathulate, obtuse, obscurely apiculate.

Nos. 2 and 3. Spathulate, obtuse, apiculate, tapering to a narrow base.

Ultimate leaves obovate-spathulate, cuspidately acute, subcartilaginous at the margin, obscurely alternately penninerved with the nerves ascending, then spreading and lastly somewhat incurved.

Statice macrophylla, *Brouss.*, *var.* flabellata.

Hypocotyl very short, erect, terete, glabrous, reddish.

Cotyledons spathulate, obtuse, minutely emarginate with a distinct midrib, glabrous, light green, 1·7 cm. long.

Stem very short, developing slowly, and becoming woody; primary internodes undeveloped.

Leaves radical and ultimately cauline, ciliate, otherwise glabrous, aristate at the apex, with a distinct midrib, and indistinctly alternately penninerved, light green; petioles flattened above, dilated and clasping at the base, ciliate at the margin.

Nos. 1 and 2. Rotund, cuneate at the base.

No. 3. Broadly obovate, rounded at the apex, cuneate or tapering at the base.

Statice Suworowi, *Regel* (fig. 496).

Primary root as in S. speciosa; annual.

Hypocotyl subterranean, tapering, 3 mm. long.

Cotyledons linear-spathulate, obtuse, glabrous, narrowed to a petiole, 7·5 mm. long including the petiole, 1·75 mm. wide near the apex.

Stem herbaceous, annual.

Leaves as in last species; soft, fleshy in the young state; petioles grooved above, convex on the back, dilated and sheathing at the base.

No. 1. Small, spathulate-linear.

No. 2. Narrowly spathulate, obtuse.

No. 3. Spathulate, subacute.

No. 4. Spathulate, aristate, scalloped at the base with a rounded lobe on each side; lobes always alternate on all the following leaves.

No. 5. Oblong, aristate, constricted below the middle; terminal lobe ovate; lower one subrhomboid, slightly decurrent on the petiole.

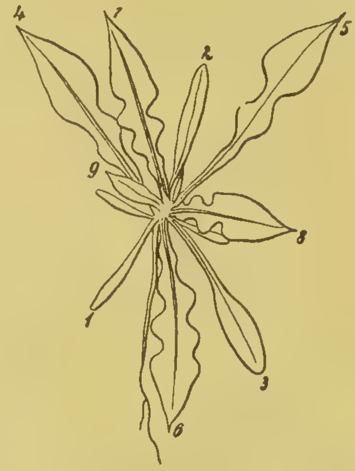

Fig. 496.—*Statice Suworowi*. Nat. size.

Nos. 6–8. Narrowly oblong, scalloped with rounded lateral lobes, and an ovate aristate terminal one.

Ultimate leaves oblong or obovate-oblong, obtuse, aristate at the apex, scalloped or subpinnatifid, with alternate or sub-opposite, obtuse lobes, obscurely and alternately penninerved, with ascending nerves running into the lobes.

Statice leptostachya, *Boiss.*

Primary root slender, tapering downwards, with numerous slender lateral rootlets, annual.

Hypocotyl not developed or tapering into, and indistinguishable from the root.

Cotyledons linear, obtuse, tapering into a long petiole-like base, slightly channelled above, and much dilated at the extreme base, glabrous but with small depressions on the upper surface, and prominences towards the top, green with a reddish base, 1·4–1·6 cm. long, ·5–1 mm. wide.

Stem extremely short, herbaceous, annual, and throwing up a scape when about to flower. Internodes undeveloped.

Leaves radical, glabrous, but covered with minute, scale-like dots, obscurely alternately penninerved, pinnatisect with linear, obtuse, entire segments, revolute at the margins so as to make them convex above, and concave or furrowed beneath; petioles semi-terete, glabrous, channelled above with rather acute edges, reddish, dilated and clasping at the base.

No. 1. Linear, pinnati-fid or -sect, with a few subulate, obtuse, alternate segments; middle ones longest; terminal one triangular-hastate.

Nos. 2–6. Gradually longer and larger, pinnatisect with alternate, obtuse, subulate and linear segments; terminal lobe becoming less and less conspicuous until it is almost absent, the leaf ending in two lateral segments.

Armeria grandiflora, *Hort.*

Fruit a one-celled utricle, one-seeded.

Seed narrow, oblong 1–1·25 mm. long, testa thin, membranous, smooth; hilum inconspicuous.

Endosperm scanty, surrounding the embryo, white, farinaceous.

Embryo straight, whitish-green; cotyledons linear-oblong, obtuse, entire, plano-convex, lying face to face; radicle short, subacute, terete, considerably shorter than the cotyledons.

Armeria chilensis, *Boiss.*

Primary root long, tapering downwards, fibrous.

Hypocotyl extremely short and subterranean, or indistinguishable from the base of the root.

Cotyledons linear-spathulate, obtuse, entire, tapering to the base and connate, forming a sheath to the plumule, the midrib indistinct, glabrous, bright green, 1·1–1·6 cm. long.

Stem with undeveloped internodes.

Leaves simple, entire, radical, alternate, tufted, very thinly pubescent in the young state or almost glabrous, sessile or at least the primary ones.

Nos. 1 and 2. Linear, obtuse, showing a midrib only which is shallowly furrowed on the upper surface and more conspicuously so beneath, narrower than the cotyledons.

PRIMULACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 628.

Fruit and Seed.—The ovary is superior or rarely more or less inferior as in Samolus; and consists of five or six carpels cohering so as to form one cell. The ovules are numerous or few, but never less than two and inserted upon a free-central, sessile, or stalked placenta, on the surface of which they are placed or are immersed in it, semianatropous with a ventral attachment or rarely anatropous as in Hottonia. The fruit is a capsule dehiscing by two to six valves (very frequently five) with the valves entire or bifid, very rarely is it circumscissile as in Anagallis, or indehiscent as in a few species of Lysimachia. The seeds are few or numerous, arranged on the surface of the central placenta or immersed in it, peltate or attached by the ventral face and very frequently depressed and variously angled. The membranous testa is smooth, furrowed or granular, sometimes winged and adnate to a copious fleshy endosperm. The embryo is small, terete or cylindrical, and lies embedded in the endosperm parallel or crosswise to the hilum, rarely pointing to it and often uncertain in its direction. The cotyledons are blunt and very small, but become foliaceous during germination.

Seedlings.—In the Primulaceæ, three distinct types of cotyledons were observed. The leading and most characteristic type is ovate; a few are spathulate or show some modification of that form; and in Cyclamen we have a reniform, foliaceous and solitary cotyledon. One of the most highly developed forms is that of Lysimachia ciliata (fig. 501), the cotyledons of which are ovate, acute and greatly resemble the first pair of leaves although smaller and with a less evident venation. Those of Anagallis arvensis are lanceolate-ovate, while the leaves from the first are broadly ovate, opposite, decussate, glabrous, but marked with black spots beneath. A considerable number of the species of Primula have ovate cotyledons, including P. veris and P. denticulata. The first leaf of the former is cordate, entire or slightly toothed, while that of the latter is widely and shallowly crenate. P. denticulata is also notable for the shortness of its hypocotyl and the length of the petioles of the cotyledons which compensate for this deficiency. The cotyledons of P. elatior (fig. 497) differ in being ovate-oblong and trinerved. The first leaf is reniform, and the second is rotund-cordate; both are dentate. The cotyledons of Androsace rotundifolia on the other hand are broadly ovate and short. The first leaf is somewhat triangular and entire or tridentate; and succeeding ones vary between reniform and orbicular, palmately nerved and lobed. A modification of the ovate type occurs in P. vulgaris and P. sinensis. Those of the former (fig. 498) are ovate, emarginate, three- or faintly five-nerved, and finely glandular-pubescent. The first two leaves are ovate. This species is remarkable for the behaviour of the radicle and hypocotyl under different conditions and in different soils. In sand the radicle strikes down vertically, but in soil of a stiffer nature it generally grows along the surface for some little way before striking downwards, and the hypocotyl generally bends in the same way and throws out lateral rootlets, abundantly provided with root-hairs. The radicle soon ceases to elongate and, gradually dying away as a procumbent stem or rhizome is formed, gives rise to the popularly so-called præmorse root. The cotyledons of P. sinensis (fig. 499) are normally broadly ovate and emarginate, but they frequently behave in an irregular manner, one of them often being bifid or bipartite and sometimes divided to the base of the petiole making apparently three cotyledons. In those that are bifid the midrib becomes forked at some distance below the sinus. Both cotyledons are bifid in some cases; and they are coarsely hairy and glandular. The primary leaves are cordate and more or less lobed and toothed. A second type is met with in Soldanella. The cotyledons are oval and obtuse at either end. The first three leaves are reniform and entire. Spathulate cotyledons are met with in Androsace nana. The primary leaves are narrower, linear-lanceolate, entire and arranged in a dense rosette. Those of Asterolinum splendidum are similar in shape but opposite and decussate, with the internodes more elongated. The cotyledons are linear-spathulate or oblong. A fourth type is presented by Cyclamen. This genus has only one cotyledon which soon becomes foliaceous and of large size resembling a true leaf. The cotyledon of Cyclamen persicum is cordate and more or less crenate, greatly resembling the first true leaf. In a batch of seedlings, individuals may frequently be found having the cotyledons consisting of two reniform, sessile, or stalked pieces resembling a compound leaf with a pair of leaflets. The apparently compound character is perhaps due to the union of the petioles of the cotyledon and the first true leaf, as occasionally happens in the case of the peduncles and the leaves.

Primula elatior, *Jacq.* (fig. 497).

Primary root normal, ultimately giving way to the strong adventitious roots developed below the cotyledons and the rosette of leaves.

Hypocotyl slender, about 6 mm. long, colourless.

Stem a short, persistent, fleshy, or almost woody rhizome with undeveloped or slightly developed internodes.

Cotyledons ovate-oblong, obtuse, somewhat succulent, pale green, glabrous; lamina 5–7 mm. long, 3–4 mm. wide; petiole slightly channelled above, slightly pubescent, 3·5 mm. long.

Leaves simple, radical, alternate, exstipulate, petiolate, rugose, glabrous above, hairy beneath; petioles (in young plant) deeply channelled above, not winged, hairy, almost villous on the under side.

No. 1. Reniform, repand-dentate, with short, broad, mucronate teeth, and a diverging basal sinus, reticulate.

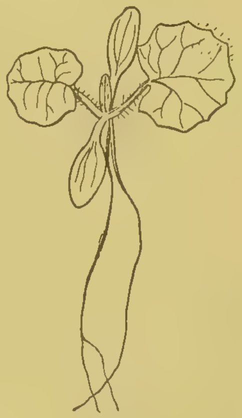

FIG. 497.
Primula elatior.
Nat. size.

No. 2. Rotund-cordate, dentate-serrate, convex above with recurved mucronate teeth.

Ultimate leaves oblong-ovate, abruptly decurrent on the petiole, shallowly and subrepandly dentate, alternately penninerved, reticulate, rugose.

Primula denticulata, *Sm.*

Hypocotyl subterranean or short.

Cotyledons apparently springing straight from the root, ovate, obtuse, with ascending petioles, from 3–4 mm. long, finely ciliated; midrib indistinct.

Stem apparently none.

Leaves radical, petiolate; the first one is ovate, obtuse, cordate at the base, crenate, ciliate and covered with small hairs, light green; midrib with numerous branched lateral veinlets.

Primula vulgaris, *Huds.* (fig. 498).

Primary root behaving differently in different soils. In silver sand a number of specimens examined penetrated the soil perpendicularly. In loam with a mixture of sand the radicle or base of the hypocotyl bends or becomes procumbent in many instances before penetrating the soil. In some cases it soon ceases to elongate and throws out strong lateral rootlets furnished with an abundance of root-hairs.

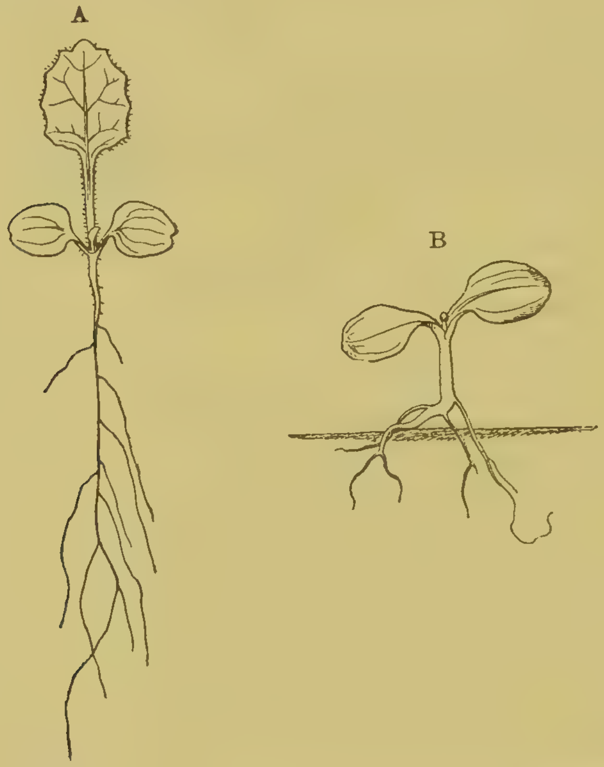

Fig. 498.—*Primula vulgaris.* A, grown in sand. Nat. size. B, grown in loam and sand, × 2.

Hypocotyl erect (at least primarily), terete, densely clothed with a glandular pubescence, pale green, throwing out strong adventitious roots at its base with an abundance of root-hairs.

Cotyledons ovate, obtuse, emarginate, finely glandular-pubescent all over, petiolate, alternately incurvinerved, with two strong nerves from near the base on either side the prominent midrib, the two upper are stronger, and incurving unite with the midrib in the apical sinus; lamina 5–7 mm. long, 5–6 mm. wide; petiole channelled above, glandular-pubescent, 2·5–3·5 mm. long.

Stem always short, with undeveloped internodes, fleshy, ultimately forming a persistent rhizome.

Leaves radical, alternately penninerved, reticulate, rugose, with more or less branched and flexuose nerves running into the marginal teeth, finely glandular-pubescent in the seedling stage, and more or less coarsely hairy in the adult plant or subvillous beneath, light green; petioles semiterete, dilated towards the base, deeply channelled above, coarsely hairy and glandular-pubescent, or subvillous in the adult plant.

No. 1. Ovate, obtuse, suddenly tapering at the base into the petiole, irregularly dentate, with the teeth tipped with a gland-like mucro, even or slightly rugose.

No. 2. Similar but more rugose.

Primula sinensis, *Lindl.* (fig. 499).

Primary root tapering, flexuose, with fibrous lateral rootlets, somewhat bent or curved at its junction with the hypocotyl, from which strong adventitious roots are generally developed at an early age—all abundantly provided with root-hairs.

Hypocotyl as in P. vulgaris.

Cotyledons broadly ovate, obtuse, emarginate, mucronate in the notch, subcordate and trinerved at the base, the lateral nerves branching so as to form five; alternately nerved and reticulate upwards (nervation indiscernible except by transmitted light), glandular-pubescent on all parts, but especially on the upper surface; lamina 5·5–8 mm. long, or more when fully developed, 5–7 mm. wide; petiole 1·5–2·25 mm. long, semiterete, channelled above, glandular-pubescent, pale green.

When the cotyledons divest themselves early of the testa and remains of the endosperm it is seen that there is no emargination, and the mucro is the most prominent point of the cotyledon. This mucro consists of clear, colourless tissue embedded in the tissue of the cotyledon with its lower and cuneate end in direct communication with the midrib, and that again with the vascular bundle running down the hypocotyl and entering the root. The midrib tipped with the mucro ceases to develop after a time while the surrounding tissue grows, resulting in emargination. Variations from the above type occur irregularly in different individuals. There are a few large openings in the mucro, confined to the very tip.

The midrib in some cases forks a little way above the base of the cotyledon, diverges and runs to the margin where each fork ends in a mucro. Fission occurs between these two mucronate tips in one, or occasionally both cotyledons while yet in the seed. After germination the mucronate tip ceases after a time to elongate, and growth of the surrounding tissue causes the emargination of both halves of the cotyledon. In this case there is a median fissure, and two shallower lateral ones.

The forking of the midrib in other seedlings may arise below the base of the lamina when the cotyledon becomes more or less deeply bifid. Again this forking may be carried down so far that one (seldom or never both) cotyledon is divided nearly to the base of the petiole, when there appear to be three distinct cotyledons with laminæ and petioles.

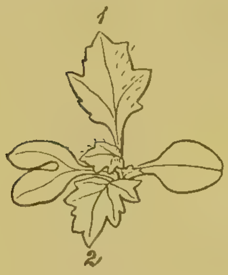

Fig. 499.
Primula sinensis.
With bifid cotyledon.
Nat. size.

When the seed is carried up on the tips of the cotyledons, the latter as they develop make a great but unsuccessful effort to divest themselves of the now dried-up testa and remains of the endosperm. The sides of the laminæ become revolute longitudinally at an early stage so as to present their outer surface to the light. At length only the tip of the cotyledons is held fast; and the petioles twist so as to bring the upper surface of the laminæ outwards to the light.

In deeply bifid cotyledons the division of the central vascular bundle takes place low down in the petiole; a branch runs down the centre of each half to the apex, where it is tipped with a mucro.

Stem short, stout, fleshy with scarcely developed internodes.

Leaves coarsely hairy on both surfaces and dotted with sessile glands, dull green above, paler beneath, sometimes suffused or coloured brownish-red; petioles semiterete, channelled above, coarsely hairy and glandular, dilated and sheathing at the base.

No. 1. Cordate, obtuse, five-nerved at the base, and alternately penninerved upwards, becoming doubly dentate-serrate.

No. 2. Cordate, subacute, lobulate with the lobes somewhat dentate. No. 3 is similar, or more decidedly lobulate.

Androsace rotundifolia, *Hardw.* (fig. 500).

Primary root quite normal.

Hypocotyl very short, tapering downwards, slightly pubescent, very pale and marked with red dots; 1·5–2 mm. long.

Cotyledons short, ovate, obtuse, entire, thinly glandular-pubescent, tipped with a minute tooth, without discernible venation when fresh; lamina 2–3 mm. long, 1·75–2·25 mm. wide; petiole flattened or slightly grooved above, thinly glandular-pubescent, 1–1·25 mm. long.

Stem herbaceous, developed when about to flower; primary internodes undeveloped.

Leaves simple, radical, alternate, palmately three- to five-nerved, and lobed or toothed, glandular-pubescent (with the hairs tipped by a red gland), dull opaque green above, suffused and mottled with red beneath; petioles semiterete, channelled above, densely glandular-pubescent with red glands, very pale green, mottled and striated with red, dilated and clasping at the base.

No. 1 (and in small seedlings sometimes No. 2). Cordate-triangular, obtuse, entire or with a minute glandular tooth on each side, tipped with an obtuse glandular tooth, obscurely trinerved.

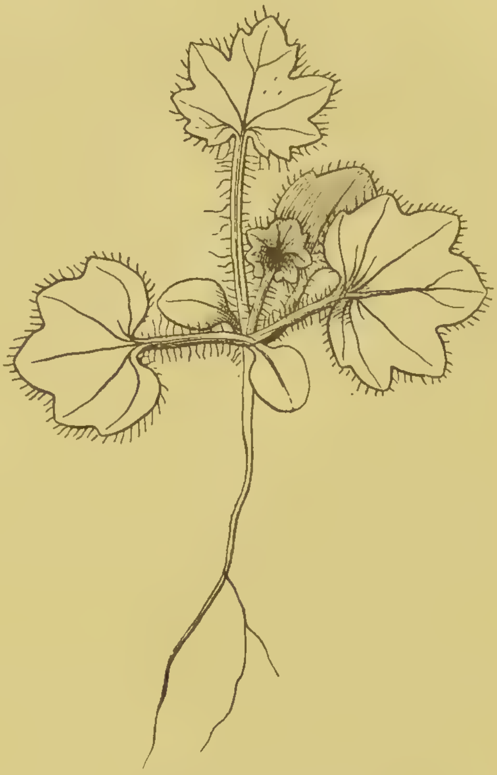
FIG. 500.—*Androsace rotundifolia*, × 3.

No. 2. Similar or larger and reniform, five-nerved and five-toothed.

No. 3. Rotund-reniform, five-nerved, obtusely five-toothed.

No. 4. Rotund-cordate, five- to seven-nerved, and toothed or sublobulate.

Androsace nana, *Hornem.*

Hypocotyl erect, terete, glabrous, 8–12 mm. long, pale green or colourless.

Cotyledons slightly obovate or spathulate, 6–7 mm. long including the short petiole, glabrous, dark green; venation very indistinct.

Stem as in last species.

First leaves radical, arranged in a rosette, entire, linear-lanceolate, acute, hispid (hairs very short and stiff), tapering to the base, almost petiolate, with a midrib, but no lateral nerves apparent.

Soldanella sp.

Primary root long, slender, tapering somewhat abruptly below the cotyledons, with numerous fibrous rootlets.

Hypocotyl not appearing above the soil, scarcely developed.

Cotyledons minute, ovate, obtuse, entire, petiolate, glabrous, green, without any distinct venation; the surface is covered with numerous minute pit-like depressions.

First leaves simple, entire, radical, alternate, oblate or almost reniform, obtuse, slightly and shallowly cordate at the base, exstipulate, glabrous, dark green, trinerved; petioles long, shallowly furrowed or channelled on the upper side.

Cyclamen persicum, *Mill.*

Primary root simple, flexuose, with numerous root-hairs, and soon assisted by numerous adventitious rootlets as strong as itself, springing from the base of the hypocotyl.

Hypocotyl globose, fleshy, almost colourless at first, becoming afterwards pinkish, then darker, ultimately brown, covered at an early stage with minute brown hairs, forming the persistent rootstock of the plant, and gradually attaining a considerable size.

Cotyledon one, cordate, obtuse, gradually enlarging and performing the functions of a leaf which it resembles in all respects, alternately and incurvedly penninerved, each lateral nerve uniting with the one above it, and giving off branches towards the margin which form a series of reticulations as the lamina enlarges, crenate, frequently bearing smaller teeth between, and sometimes glandular papillæ, glabrous above, deep opaque green, or finally with pale green or greyish markings, minutely pubescent beneath, and generally deep red; petiole long, terete at the base, shallowly channelled upwards, minutely pubescent, pale green or more often stained with red.

Exceptions occur where the cotyledon assumes the appearance of a compound leaf. Occasionally there are two reniform laminæ on a common petiole united to the very apex, while at other times the petiole is separated into two for some considerable way down, each bearing a reniform, crenate or angled lamina. Sometimes three leaves are thus united with the cotyledon instead of one, and when the lower pair is small they appear like stipular organs at the top of the petiole. The venation of each lamina is similar to that of an ordinary cotyledon. In a pot of eighteen seedlings, eight showed some such monstrosity. The petioles of the adult plant are occasionally adnate to the peduncles, which thus assume a caulescent appearance.

Leaves simple, radical, alternate, exstipulate, petiolate, radiately five-nerved in seedlings, ultimately seven- to nine-nerved, irregularly crenate at the margin, glabrous above and deep green marked with grey, paler beneath, or more or less suffused with red, minutely and papillosely pubescent; petiole subterete, shallowly grooved towards the base, papillosely and minutely pubescent.

No. 1. Reniform, five-nerved with the nerves radiating and incurved towards their tips where they branch and anastomose.

Ultimate leaves broadly cordate, obtuse, seven- to nine-nerved, with the midrib and some of the stronger nerves more or less alternately penninerved; all the lateral nerves incurve towards their tips, and give off strong branches on their posterior side towards the margin, forming large reticulations. Small branches are given off into the crenatures.

Gressner (Bot. Zeit. 1874, p. 837) says there is a slight eminence which represents the second cotyledon, and which subsequently develops into a leaf, so that Cyclamen has two cotyledons which resemble leaves. Richard, Treviranus, and Gaertner (who first wrote about it) say only one.

The germination of Cyclamen has been described by Gaertner,[1] Richard,[2] Mirbel,[3] Treviranus,[4] Gressner,[5] and Darwin.

The cotyledons first appear as two small eminences, one of which makes no further growth, while the other develops into a green cotyledon resembling the true leaf of the plant.

Dr. M. T. Masters (Gardener's Chron. 1887, p. 596) agrees with Gaertner and Treviranus, as against Mirbel, that there is only one cotyledon, but the first two, three, or even four leaves sometimes have their petioles connate.

Lysimachia ciliata, *L.* (fig. 501).

Primary root tapering downwards and flexuose, giving off a few lateral rootlets, but soon superseded by strong adventitious roots from the hypocotyl.

Hypocotyl short, erect, thickened upwards, glabrous, closely and minutely dotted with red, 4–5 mm. long.

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[1] *Carpologia*, vol. iii. p. 25.

[2] *Analyse du Fruit*, Paris, 1808, p. 83. English translation by Lindley, *Fruits and Seeds*, London, 1819, p. 71.

[3] *Ann. du Musée*, vol. xvi., 1811, p. 454, tab. xvi.

[4] *Symb. Phyt.* Fasc. i., 1831, p. 86, and tab. iii., figs. 66–71.

[5] *Bot. Zeit.* 1874, pp. 801, 17, 31.

Cotyledons ovate, acute, entire, glabrous, with a distinct midrib, but no other venation discernible, deep green above, paler beneath; lamina 4–7 mm. long, 3–6 mm. wide; petiole channelled above, convex on the back, 2·5–6 mm. long, slightly connate at the base, glabrous, dotted with red.

Stem herbaceous, throwing up annually leafy, flowering stems from a persistent rootstock, quadrangular, densely covered with a glandular pubescence; 1st internode ·5–1·25 mm. long; 2nd 1–3·5 mm.; 3rd 1–10 mm.

The internodes are more developed when the seedlings are crowded than when they have plenty of space.

Leaves simple, entire, cauline, opposite, alternately incurvinerved, obscurely reticulate, minutely glandular and deep green on the upper surface, paler beneath; petioles semiterete, channelled above, more or less thinly ciliate along the edges in the seedling stage, but more decidedly so in the adult plant with coarse hairs or fringes, slightly connate at the very base.

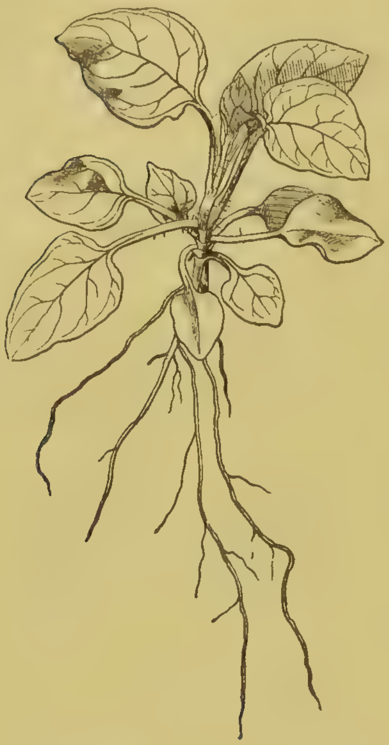
FIG. 501.—*Lysimachia ciliata.* Nat. size.

First pair ovate, obtuse, similar to the cotyledons, but slightly larger.

Second to fourth pairs ovate, gradually larger and more acute.

Asterolinum splendidum, *Auct.*

Hypocotyl erect, terete, glabrous, colourless below the soil, green above it, 1–1·5 cm. long.

Cotyledons linear-oblong, obtuse, glabrous, tapering at the base but scarcely petiolate, entire, 8–10 mm. long, 1–2 mm. wide, bright green, lighter beneath, buds which develop into branches are formed in their axils.

Stem herbaceous, erect, terete, glabrous, pale green; 1st internode 3–3·5 mm. long; 2nd only from 1·5–2 mm.

Primary leaves cauline, simple, opposite, decussate, sessile, entire, linear-lanceolate, acute, glabrous, light green.

Anagallis arvensis, *L.*

Hypocotyl erect, terete, glabrous, 5–8 mm. long, almost colourless, with occasionally a slight reddish tinge.

Cotyledons ovate-lanceolate, obtuse, entire, glabrous, green with brown spots beneath, indistinctly one-nerved; petioles short, very slightly flattened above.

Stem erect, or procumbent in rich soils, quadrangular, herbaceous; 1st internode 5–6 mm. long; 2nd shorter.

First leaves simple, entire, cauline, opposite, decussate, broadly ovate, obtuse or subacute, glabrous, green with dark spots beneath, trinerved at the base.

MYRSINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 639.

Fruit and Seed.—The ovoid or globose ovary is superior, or inferior in Mæsa, one-celled with few or numerous ovules inserted on a free-central globose placenta or deeply immersed in it, amphitropous or anatropous. The fruit is globular, drupaceous or baccate, with a pulpy exocarp and a crustaceous endocarp, one- or few- very rarely many-seeded. The seed is nearly always solitary and globose, conforming to the interior of the cavity, often umbilicate at the base with a shallow or deep cavity owing to a thickening or swelling of the placenta the sides of which are prolonged into a cup-shaped membrane surrounding the base of the seed. Much more rarely the seeds are numerous and small or relatively large, tumid, bluntly angled and obliquely affixed to the placenta. The testa is membranous and closely adheres to the copious, fleshy or horny, smooth or ruminated endosperm. The embryo when normal is transverse to the placenta in all cases where the seed is solitary; but where the seeds are more numerous in a fruit, the embryo is more or less axile or excentric, and cylindrical, curved or arcuate. The cotyledons are small and of the same width as the radicle, which is elongated and terete; in some cases they are foliaceous.

The fruits observed all belong to the genus Ardisia, and are globose, drupaceous, and one-seeded. The seed is shallowly indented at the base, while on the other hand there is a slight swelling at the micropyle caused by the radicle being closely pressed against it. The embryo when normal is transverse to and parallel with the placenta, but there are exceptions when more than one embryo occurs in a seed.

The fruit of Ardisia polycephala is depresso-globose, and considerably flattened on the top. The embryo is terete and thickened or clubbed at the tip of the radicle, with the back of the cotyledons to the placenta. The fruit of A. japonica (fig. 504) is perfectly globular with exception of the basal indentation. The seed presents the remarkable peculiarity of often containing several embryos, as many as six being sometimes present. The radicle in such a case points in various ways, and in germination each embryo makes its exit at different places. Even although the embryo is solitary in a seed of A. crenulata, it is nearly always excentric and ascending. The cotyledons of this species never leave the seed, but during germination they attain a considerable size, and become slightly convolute with the edge of one within that of the other.

Seedlings.—There is considerable variation amongst the seedlings of this Order, and of the four genera and eight species observed hardly any two are exactly alike in form as far as the cotyledons are concerned. Those of Mæsa argentea are small, oval, and entire. The first leaf is ovate and serrate, the size rapidly increasing in succeeding ones. The cotyledons of Jacquinia ruscifolia are oblong-ovate, coriaceous, and very persistent. The first pair of leaves are opposite, elliptic, and larger than the cotyledons. The second pair are also opposite, smaller, and sometimes at least very unequal in size. After this the leaves are lanceolate-elliptic, and whorled.

A very remarkable case occurs in Embelia Ribes (fig. 502) the cotyledons of which are ovate, acute, glandular-ciliate and finely serrate along the whole margin in the young state, but ultimately on the upper half only, owing apparently to intercalary growth at the base. The venation of the full-grown cotyledons would seem to indicate the same fact, for the trinerved condition of the upper part is evidently that most commonly characteristic of cotyledons, while the venation of the lower half corresponds to that of the leaves. The first leaf is similar in shape to the cotyledons but smaller. Succeeding ones are larger and gradually pass through ovate and elliptic to lanceolate forms. The plant itself is shrubby, erect at first, but ultimately climbing.

The cotyledons of Embelia viridiflora are large, elliptic, somewhat undulated, entire, and persistent. The growth of the stem is very much interrupted, and at the lower part of each growth some of the leaves are small and scale-like, followed by a few that are similar in shape to the cotyledons but larger.

The four species of Ardisia examined have cotyledons widely different in form, and differ more or less widely in their mode of germination. The cotyledons of A. polycephala (fig. 506) are elliptic, emarginate, foliaceous, and persistent, with an incurved penninerved venation like that of the leaves, the first two of which are similar, but larger and entire. Succeeding ones rapidly increase in size, but especially in length.

In A. mamillata (fig. 505) the hypocotyl is short but very stout and fleshy. The cotyledons are aerial but small, oblate, bifid and hairy. Those of A. crenulata (fig. 503) are small, spathulate, and petiolate, but never leave the seed. The latter if fairly well covered with soil remains underground, when the petioles of the cotyledons attain a few millimeters in length; but if the fruit with its seed is uncovered the cotyledons are almost sessile, and the seed gets carried up by the elongating hypocotyl. This is more decidedly the case in A. japonica (fig. 504), the hypocotyl of which varies from 1·3–3 cm. in length. The cotyledons are small, ovate and never leave the seed, which therefore gets carried up with the growth of the seedling. The petioles of the cotyledons are both directed to one side of the axis, flattened, pubescent, and become undulated as they lose substance and fade. The first three leaves vary from oval to rotund and ovate, and are serrate like the adult leaf which is evergreen. Several seedlings often proceed from the same seed, as mentioned above.

Mæsa argentea, *Wall.*

Hypocotyl short, erect, terete, glabrous, ·75–1 mm. long greenish.

Cotyledons small, ovate or oval, obtuse, entire, petiolate, glabrous, green, one-nerved; petioles short, channelled above.

Stem erect, terete, herbaceous, ultimately woody, stout, pubescent; 1st internode about 1 mm. long; 2nd 1·5–2 mm.; 3rd, 4th, and 5th rather longer.

First leaves simple, cauline, alternate, exstipulate, petiolate, oblong, acuminate, coarsely serrate, covered when young with a minute pubescence, afterwards apparently glabrous, green, distinctly pinnatinerved; petioles stout, deeply channelled on the upper face.

Embelia Ribes, *Burm.* (fig. 502).

Primary root normal, but soon superseded by strong adventitious roots from its base, or from the base of the hypocotyl.

Hypocotyl erect, terete, densely and finely glandular-pubescent, pale green spotted or striped with brown, 2–2·5 cm. long.

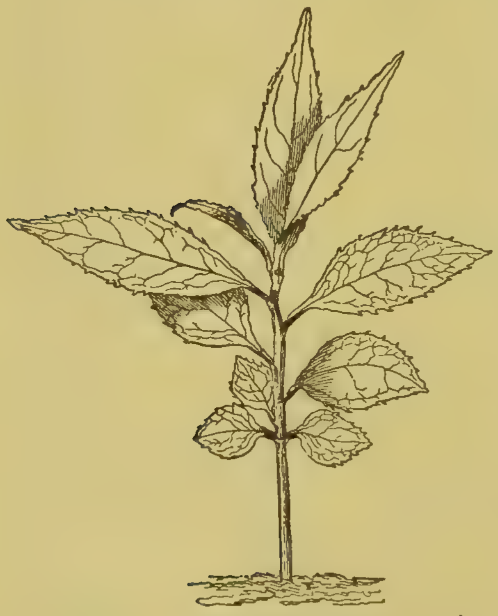

FIG. 502.—*Embelia Ribes.* Half nat. size.

Cotyledons ovate, obtuse or subacute, indistinctly alternately incurvinerved and reticulate, distantly serrate in the upper half, tapering into a petiole, bright green and shining above, much paler beneath, and dotted with sunken black glands, thinly glandular-pubescent at the margins when young; lamina 1·4–1·5 cm. long, 9·5–11·5 mm. wide; petioles semiterete, slightly furrowed above, finely glandular-pubescent, forming a slight rim around the stem at their base, 2·5–3·5 mm. long.

Stem erect in the young state, terete, finely glandular-pubescent, subflexuose, pale green minutely dotted with brown, ultimately woody and scandent; 1st internode 2·25–5 mm. long; 2nd 3·5–5 mm.; 3rd 2·5–4 mm.

Leaves alternate, alternately incurvinerved, and indistinctly reticulate, rather thick, shining on both surfaces, bright green above, paler beneath and glandular, thinly glandular-pubescent on both surfaces; petioles semiterete, channelled above, thickly glandular-pubescent, tapering downwards and articulated with the stem.

No. 1. Broadly ovate or short elliptic, acute, serrate except towards the base.

No. 2. Elliptic, otherwise like the first.

Nos. 3 and 4. Lanceolate-elliptic, acute, tapering and entire at the base.

Nos. 5–7. Lanceolate, acuminate, otherwise similar to Nos. 3 and 4.

Embelia viridiflora, *Scheff.*

Hypocotyl woody, 3–5 cm. long, about 3 mm. thick, terete, glabrous, lenticelled, greyish-brown.

Cotyledons shortly petioled, 2·5–3·5 cm. long, nearly 2 cm. wide, elliptic-lanceolate, subacute at the base, penninerved, with sunk midrib and an entire undulate margin, quite glabrous, somewhat leathery, shining dark green above, very slightly paler beneath, very persistent.

Stem like the hypocotyl, with internodes of very unequal length; the younger part succulent and bright green.

Leaves entire, glabrous, coriaceous, intense green on both sides, beset with black translucent glands of two forms, round and oblong or linear; petioles short, flat or channelled above, somewhat margined in the upper part by the decurrent lamina.

The first leaf is very little above the cotyledons, and exactly like them except for the translucent glands.

Succeeding ones are only larger and more distant from each other—most of the glands are round, but some are oblong or linear.

This interesting plant presents interrupted growth within a small space of time similar to that of many fruit trees. In the present case four distinct growths occurred in the primary axis not more than 10 cm. long, namely, one growth ending in the seed leaves 4·8 cm. long; a second consisting of the first four internodes 8 mm. long; the next about 2·8 cm.; and the last only 1·5 cm.

Furthermore the shoots of the stem bear one, two or more alternate small leaves or scales on their lower part, and generally only two well-formed leaves at the top.

Ardisia crenulata, *Vent.*

Fruit a drupe, globose, indented or umbilicate at the base, minutely so at the apex, glabrous, deep bright red when mature;

epicarp thin; mesocarp pulpy, pale pink or almost colourless; endocarp crustaceous, marked longitudinally from base to apex with strong, simple or somewhat forking nerves; placenta prominent, causing a slight indentation in the base of the seed, and thinned away towards the sides, forming a cup round the base of the seed.

Seed solitary, globose, slightly indented at the base, conforming to the cavity of the ovary; testa thin, pale brown, membranous.

Endosperm fleshy, subtransparent, firm, but when dry horny, constituting the greater bulk of the seed.

Embryo straight, transverse to the seed, or more often ascending, more than half the width of the seed, but proportionately much shorter than that of A. japonica or A. polycephala, 2·75–3·25 mm. long; cotyledons minute, ovate, obtuse, entire, colourless, lying with their edges perpendicular to the hilum; radicle cylindrical, stout, obtuse, abutting against the testa and causing a slight elevation, pale greenish, several times longer than the cotyledons, horizontal or more often ascending.

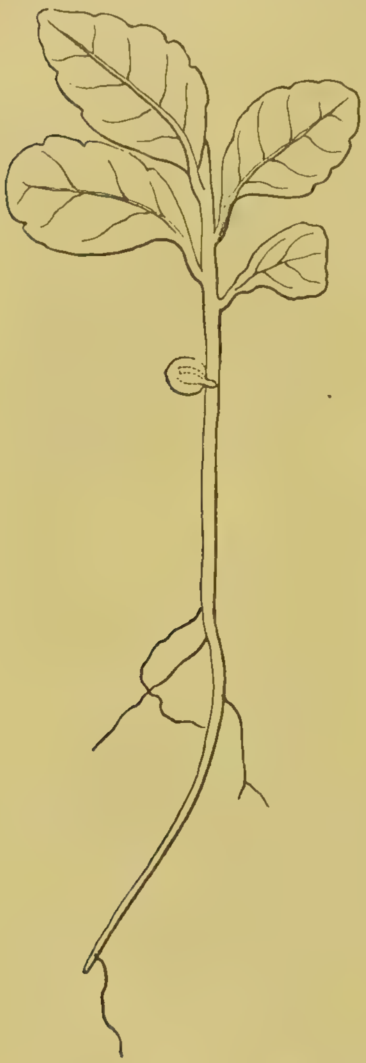

Fig. 503.—*Ardisia crenulata.* Nat. size.

Seedling (fig. 503).

Primary root long, fleshy, gradually tapering, giving off a few scattered lateral rootlets.

Hypocotyl terete, fleshy, stout, pale or dirty white beneath the soil, and pale green dotted with red above it, minutely pubescent, about 2 cm. long, 1·5–2 mm. thick.

Cotyledons spathulate, remaining in the testa until the endosperm is exhausted, and carrying up the testa with them, ultimately perishing and falling away.

Stem erect, terete, fleshy and soft, ultimately frutescent, minutely pubescent, pale green dotted with red, subverrucose; 1st internode 6·5 mm. long; 2nd 2 mm.; 3rd 1·5 mm.; 4th 3·5 mm.

Leaves alternate, evergreen, crenate, obtuse or emarginate, deep green above, paler beneath, glabrous, with a row of submarginal red glands evident on both surfaces, sometimes also developing scattered glands all over the upper surface; petioles very short, flattened above or subchannelled.

No. 1. Small, spathulate or obovate, truncate.

Nos. 2 and 3. Oval, obtuse.

No. 4. Elliptic, narrowed somewhat to both ends, minutely emarginate.

Ardisia japonica, *Blum.* (fig. 504).

Fruit a globose drupe, scarlet, glabrous; epicarp thin; mesocarp pulpy; endocarp pale brown, crustaceous, marked longitudinally with strong nerves; placenta prominent, thickened, causing an indentation at the base of the seed, thinning away towards the sides and forming a cup surrounding the base of the seed.

Seed as in A. crenulata.

Endosperm copious, constituting nearly the whole bulk of the seed, subtransparent.

Embryo similar to that of the last species, but reaching almost across the seed, the cotyledons, which are equal in width to the radicle at their base and tapering towards the tip, lying just within the endosperm on one side of the seed, or directed towards the base in cases where the radicle ascends; radicle many times longer than the cotyledons.

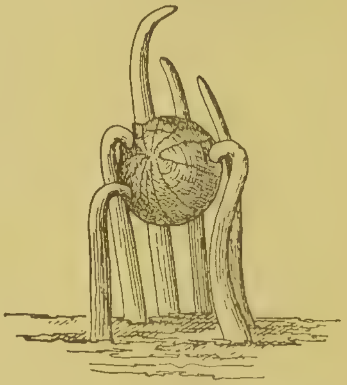
FIG. 504.—*Ardisia japonica.* Germinating seed, showing six embryos, × 2.

When the embryo is solitary it is transverse to the axis, but the number of embryos varies from one to six; when several they assume various directions, ascending, erect or suberect, and nearly or quite perpendicular to the placenta.

Seedling.

Hypocotyl similar to that of A. crenulata.

Cotyledons small, ovate, with long petioles, remaining in the seed; petioles flattened above and channelled, glandular-pubescent or ciliate.

Stem erect, terete, densely glandular-pubescent and red, at least when young, ultimately woody; first internode undeveloped; 2nd and 3rd each about ·5 mm. long.

Leaves alternately penninerved and reticulate, minutely glandular-pubescent on both surfaces, and beset with orange-coloured, pellucid glands in the tissue all round the margin of the leaf, deep green above, paler beneath, more or less shining on both surfaces, evergreen; petioles short, semiterete, channelled above, finely glandular-pubescent, reddish.

No. 1. Transversely oval, serrate, small.

No. 2. Rotund, irregularly serrate.

No. 3. Obliquely ovate, obtuse, unequally serrate, appearing rather deformed.

Ardisia mamillata, *Hance* (fig. 505).

Primary root very long, stout, tapering downwards and giving off numerous lateral branches.

Hypocotyl erect, very stout, fleshy, cylindrical or tapering somewhat to either end, minutely pubescent, 1 cm. long.

Cotyledons oblate, emarginate or obreniform, sessile, subfleshy, deep green, very hairy on both surfaces with transparent jointed hairs, which are longest on the upper surface and on the margin, convex above, revolute at the margin and concave beneath, showing a midrib very distinctly, but no other venation.

The emargination of the cotyledons appears to be due to their being convolute and closely wrapped or rolled round the plumule before emerging from the albuminous seed. The latter is round like a small pea, and the cotyledons, after attaining their full length, grow greatly in width and are accommodated in the seed by becoming convolute, as in Geranium, Eucalyptus, and others.

Leaves shortly penninerved, densely covered on the upper surface with mamillate outgrowths or emergences, upon which long coarse hairs are seated, oblong, obtuse, subcoriaceous, persistent.

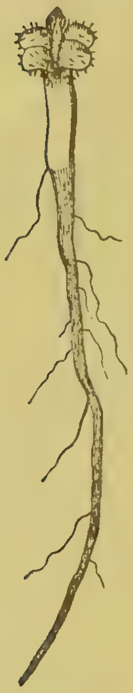

Fig. 505. *Ardisia mamillata.* Seedling, showing emarginate cotyledons. Nat. size.

Ardisia polycephala, *Wall.*

Fruit a drupe, depresso-globose or considerably flattened at the top, smooth, deep black; epicarp thin; endocarp crustaceous and marked from base to apex with strong longitudinal nerves; mesocarp pulpy, reddish or pinkish; placenta basal, prominent and protruding into the ovary, where it causes a cavity at the base of the seed, and thinning away towards the sides forms a cup round the same ; it becomes brown and membranous when mature.

Seed globose, immersed in the basal placenta, and closely filling the cavity of the ovary, depressed or rather indented at the base by the prominent thickened placenta ; testa extremely thin and membranous, pale brown.

Endosperm copious, subtransparent, fleshy when mature, horny when dry.

Embryo straight, cylindrical, transverse to the seed and parallel with the placenta, nearly equalling the width of the seed, colourless ; cotyledons minute, ovate, obtuse, lying with their backs to the basal placenta and their tips just inside the periphery of the seed, and embedded in the endosperm ; radicle nearly constituting the whole embryo, cylindrical, stout, obtuse, abutting against the testa on one side of the seed and even causing a slight prominence there.

EARLY DEVELOPMENT OF COTYLEDONS.

During germination the seeds, if but lightly buried, are carried up on the tip of the seedling ; but if moderately deep in the soil, the hypocotyl rises with a curve and finally pulls itself out of the seed and becomes erect.

The cotyledons are now oblong, obtuse, concave and closely applied to each other by their edges or more or less distinctly convolute one over the other, densely glandular, sessile or subsessile, becoming shortly but distinctly petiolate, and greatly enlarged by the twenty-third day after germination.

They then unfold or unroll, becoming flat, elliptic-ovate, obtuse or subapiculate, obsoletely dentate at the margin, alternately and irregularly penninerved, reticulate with the principal nerves running into the minute teeth by a straight or zigzag course, or often sending strong lateral branches into them.

Seedling (fig. 506).

Hypocotyl 3–4 cm. long.

Cotyledons ultimately elliptic, obtuse, emarginate, coriaceous, evergreen, glabrous, persisting for about a year, petiolate, about 2·3 cm. long and 1·6 cm. wide.

The midrib is strong, traversing the leaf and tapering upwards till near the apical sinus, where it bifurcates, a branch passing on each side of the sinus also giving off numerous lateral, ascending, slightly wavy veins, furnished with branches uniting with one another towards the margin, and forming a series of large reticulations.

Apex ending in a few large pores and forming a small, somewhat crustaceous and brittle mucro crumbling away in old specimens, while the margin elsewhere remains intact.

Stomata large, numerous on the under side, fewer on the upper.

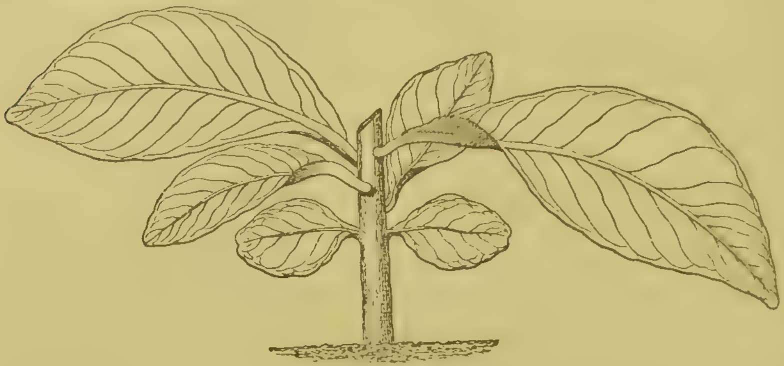

Fig. 506.—*Ardisia polycephala.* Half nat. size.

Resin or oil cavities rather numerous, brownish-orange, scattered and sunk in the tissue of the leaf.

Leaves coriaceous, persistent.

No. 1. Elliptic, obtuse, entire.

The ultimate ones exactly similar, but much larger.

Jacquinia ruscifolia, *Jacq.*

Hypocotyl woody, erect, terete, shortly pubescent, dull green, 2 mm. above the soil.

Cotyledons oblong-ovate, undulate or curling, rigid, mucronate cartilaginous at the margin, deep green above, paler beneath, glabrous, sessile, 1·5 cm. long, 7 mm. wide.

Stem woody, erect, terete, subscabrous, pale green; 1st and 2nd internodes undeveloped.

Leaves verticillate, entire, glabrous, rigid, shining, deep green above, paler beneath, subrevolute at the margin, tipped with a spine, slightly subchannelled above, more or less carinate beneath; petioles rigid, 1–2 mm. long.

First pair opposite, elliptic.

Second pair opposite, scarcely decussate, elliptic, unequal, the smaller one lanceolate.

Here the first growth terminates, and several small brown scale-leaves are produced.

When growth recommences five narrowly lanceolate leaves are produced in a whorl; above this two small, narrowly lanceolate, opposite ones.

Here growth is again arrested, and the bud is protected with small scales.

SAPOTACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 650.

Fruit and Seed.—The ovary is superior, and consists of two to five, rarely many, carpels cohering to form as many cells. The ovules are solitary in each cell, attached near the apex or at least some distance above the base of the axile placentas, and amphitropous. The hilum is ventral and usually very large. The fruit is baccate, pulpy, fleshy, more rarely thickened and dry or rarely thin, but always indehiscent. It contains as many cells as there are carpels, or by abortion it may be one-celled and one-seeded, in which case the seed is very large and conforms to the cavity. When the seeds are more numerous they are arranged around the central axis and flattened on their sides by mutual pressure. The hilum is often of great size, linear, oblong, or elliptic and frequently at least equalling the seed in length. Sometimes it is broad and confined to an area near the base of the seed. The testa is crustaceous or lignified, smooth and shining as in Lucuma. The embryo is straight with large cotyledons, and when endosperm is present they are flat and at right angles or parallel to the axis. When endosperm is wanting as in Lucuma the cotyledons are of great size and convexo-concave or variously squeezed into or overlapping one another at the edges. The radicle is always inferior and as a rule very minute compared with the cotyledons. The latter may be described as conferruminate in cases where endosperm is wanting and they attain a large size, as in a few species of Lucuma, but more decidedly in the genus Sarcosperma where the embryo is homogeneous and inseparable into its component parts. Other exceptions occur in Argania, in which the septa and axile placentas disappear during growth, and the whole of the seeds become agglomerated into a central mass. The testa of the seeds in Labatia and Argania is very thick and lignified, as is the case also in Lucuma mammosa. Endosperm is wanting in the latter and the large embryo conforms to the interior of the seed. The cotyledons are very fleshy and closely applied to one another, but readily separable, and in germination swell up so as to burst the woody testa in halves.

In Butyrospermum Parkii the ovary consists of eight to ten carpels with as many cells, each of which contains one ovule. The fruit is one- or few-seeded by abortion. The fleshy cotyledons are plano-convex and inseparable from one another, forming a mass conforming to the seed, which is variable in outline, ovoid, oblong-ovoid, or almost globose, with an oblong or elliptic hilum broadest at the upper end. The radicle is short and scarcely protruded from between the cotyledons.

Seedlings.—There are two leading types in this Order according as the cotyledons are aerial or subterranean. The cotyledons vary in shape in both cases in conformity with the seed in which they were developed. Those of Sideroxylon tomentosum are broadly ovate, rounded at the base, obtuse at the apex, coriaceous, with an incurved penninerved venation similar to that of the leaves, and very persistent. They probably endure as long as the first leaves, seeing that they were still in perfect health a year and a half after germination. The cotyledons of Mimusops Balata are oblong-ovate, obscurely penninerved, coriaceous and also very persistent. The first four leaves are obovate-lanceolate.

The seedling of Rostellaria abyssinica is much smaller than either of the foregoing, with a finely pubescent hypocotyl. The cotyledons are suborbicular, emarginate, and faintly trinerved. The primary leaves are oval, entire, penninerved and opposite.

A strikingly different type is represented by an unnamed species of Lucuma (fig. 507). The cotyledons are oblong, plano-convex, or slightly concave on the upper surface, very fleshy and narrowed to a short petiole which is connate and forms an annulus around the axis. They are subterranean or partly so, but split the testa into halves and spread out horizontally, or one is directed upwards and the other downwards. When the upper surface is exposed to the light, it develops chlorophyll and becomes green. The extreme hairiness of the young stem and lanceolate-elliptic penninerved leaves in the seedling stage at least is very noticeable. The seedling of Lucuma mammosa is very similar to the last in all the leading particulars. The cotyledons are subterranean and fleshy, but split open the woody testa during germination. The stem is very stout and is notable for the length of the first internode which measures 7–10 cm., and compensates for the want of the hypocotyl. The leaves are sometimes pseudo-verticillate, but as a rule alternate, and the first six are closely aggregated above the first internode, oblong or lanceolate-elliptic and penninerved.

The cotyledons of Butyrospermum Parkii are fleshy and subterranean like those of Lucuma ; but the first three or four leaves are small, scale-like, and caducous, while their stipules are more persistent. The next two or three are foliaceous, elliptic and penninerved.

Chrysophyllum oliviforme, *Lam.*

Primary root long, tapering, with lateral rootlets.

Hypocotyl erect, terete, glabrous, soon becoming woody, 3·5–4·5 cm. long.

Cotyledons oval, obtuse, entire, shortly petiolate, obscurely tri-nerved, opaque, fleshy, deep olive-green and convex above, much paler beneath and sometimes slightly concave, glabrous, often irregular in outline, often shortened at the apex, and in other cases somewhat oblique ; petiole plano-convex or slightly grooved above.

Stem erect, terete, or slightly compressed in the seedling, covered with a pale brown or yellowish, adpressed pubescence ; 1st internode 4 mm. long.

Leaves simple, entire, cauline, alternate except the primary ones, shortly petiolate, exstipulate, penninerved, with the nerves incurved and not reaching the margin ; petiole subterete, channelled above, covered with an adpressed pubescence.

No. 1. Lanceolate, acuminate, ciliate at the margin, slightly hairy on the ribs above at least when young, and covered with a silky adpressed pubescence beneath.

Lucuma mammosa, *Gaertn.*

Seed very large, elliptic, with a smooth woody testa.

Hypocotyl undeveloped, or short and subterranean.

Cotyledons conforming to the interior of the testa, fleshy, plano-convex, or slightly concave above, splitting open the testa during germination, but remaining in it and subterranean.

Stem stout, erect, purple-brown, pubescent, soon becoming woody; 1st internode 7–10 cm. long; several succeeding ones short. The long first internode is to make up for the non-development of the hypocotyl.

Leaves thinly pubescent.

Nos. 1–6. Oblong or lanceolate-elliptic, rather crowded above the first internode.

Lucuma sp. (fig. 507).

Primary root long, stout, tapering downwards and quite unbranched in the early stages.

Hypocotyl very short, stout, subterranean.

Cotyledons very large, fleshy, plano-convex or slightly concave on the upper surface, sessile or narrowed to very short petioles which are connate around the axis, subterranean or appearing just at the surface of the soil, bursting the woody testa into two halves and spreading horizontally, or often one becomes suberect while the other is deflexed; lamina 3–3·6 cm. long, 1·8–2 cm. wide, about 1·2 cm. thick, and becoming deep green on the upper surface when exposed to light.

Stem erect, stout from the earliest stages, and soon becoming woody, densely hairy or subvillous, terete or tapering upwards; 1st internode 5–6 cm. long; 2nd very much shorter.

Leaves as in Chrysophyllum but with parallel slender veins, showing most prominently on the under surface, ultimately coriaceous; petioles terete or subterete, densely hairy.

First pair opposite, rather small, unequal, showing that they are not truly opposite, lanceolate-elliptic, acute, slightly undulated at the margin at least when young.

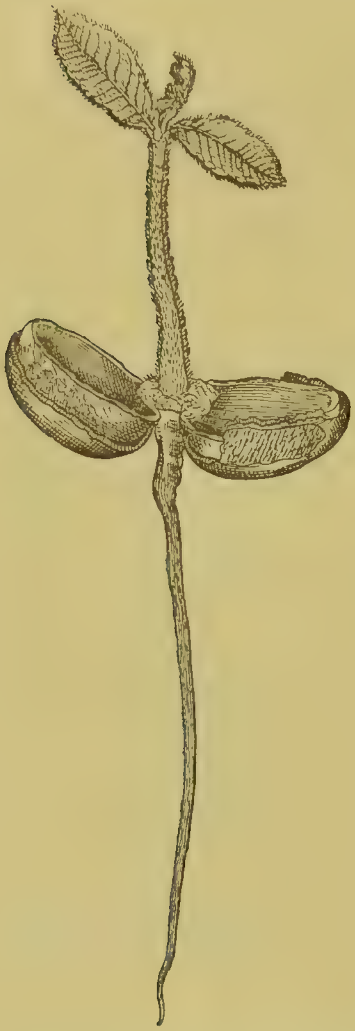

FIG. 507.—*Lucuma sp.* Showing the two halves of the testa attached to the cotyledons. Half nat. size.

No. 3. Alternate.

Sideroxylon tomentosum, *Roxb.*

Hypocotyl 3–4 cm. long, 2·5–3·5 mm. thick, terete, woody, glabrous, greyish-brown.

Cotyledons nearly equal, shortly stalked, about 3 cm. long and 2 cm. wide, ovate, rounded at the base, very obtuse at the apex, entire, pinnatinerved, coriaceous, glabrous, dark dull green above, light green beneath, very persistent, for when examined eighteen months after germination they were still in perfect condition.

Stem like the hypocotyl, decreasing in thickness and increasing in pubescence towards the top; internodes 5–15 mm. long, flexuose.

Leaves entire, alternate, subreticulate, coriaceous, tomentose when young, glabrous when old; petioles short, flattened above.

Nos. 1–12. Elliptic or oblanceolate, acuminate, entire, pinnatinerved, coriaceous, pubescent when young, dark green; lamina 4–6 cm. long, and 1·5–2 cm. wide; petiole short, stout, pubescent, often reddish, with a spine in its axil.

Ultimate leaves lanceolate-elliptic, acute, glabrous and shining on both surfaces, deep green above, lighter beneath, evergreen, alternately penninerved with ascending nerves. Many of the branches are reduced to spines one-half to three-quarters or one inch long.

Mimusops Balata, *Gaertn.*

Hypocotyl well developed and woody at an early stage.

Cotyledons very large, foliaceous, broadly oblong-ovate, obtuse, sessile, obscurely penninerved with slender ascending nerves, coriaceous, dark green, glabrous, very persistent.

Stem woody.

Leaves simple, entire, alternate, exstipulate, shortly petiolate, obscurely penninerved with slender nerves, coriaceous, persistent.

Nos. 1–4. Inclusive, obovate-lanceolate, shortly petiolate, somewhat acuminate.

Butyrospermum Parkii, *Kotschy.*

Ovary of eight to ten carpels, eight- to ten-celled, each cell one-ovuled; ovules fixed by their ventral aspect to the axis, amphitropous; micropyle inferior.

Fruit ellipsoid, baccate, one- or few-seeded by abortion; pericarp thin, fleshy.

Seed ovoid or oblong-ovoid, or sometimes almost semiglobose when it is flattened on the ventral aspect by pressure or contact with other seeds or parts of the fruit; testa brown, smooth, shining, crustaceous, and brittle; hilum on the ventral aspect, very large, oblong or elliptic, narrowed to an acute point at the lower end, but always broader and rounded at the upper end, and nearly or quite equalling the length of the seed; raphe ventral; radicle and micropyle inferior; chalaza subapical on the ventral aspect.

Endosperm absent.

Embryo straight, large, entirely filling the interior of the seed and conforming to its shape when mature, or loose and free by shrinking; cotyledons very thick, fleshy, plano-convex, applied to each other face to face and (in old seeds at least) inseparable, each occupying half the space in the seed, of variable outline like the seed, but always broadest at their bases, which rest on the lower end of the seed; radicle very slightly protruded from between their bases, short, stout.

Seedling.

Hypocotyl undeveloped.

Cotyledons thick, fleshy, subterranean.

Stem erect, woody, hairy.

Leaves slightly coriaceous, persistent, covered with rusty hairs when young.

Nos. 1–3 or 4. Alternate, small, scale-like, caducous, linear-subulate, stipulate; stipules more persistent than the leaves.

Nos. 4–6. Much larger, foliaceous, elliptic, penninerved with incurved nerves, glabrous, with short hairy petioles channelled above. Stipules very hairy, protecting the sides of the bud.

EBENACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 662.

Fruit and Seed.—The ovary is superior, sessile or rarely stipitate, consisting of two to eight carpels uniting to form as many cells, or twice the number by development of spurious and perfect or imperfect septa. The ovules are geminate in each, or twice the number of the carpels; but when false dissepiments are present the ovules are solitary in each cell; in all cases they are inserted upon axile placentas, pendulous and anatropous. The pericarp is coriaceous or fleshy and indehiscent, rarely dehiscent, and the fruit often few-celled by abortion and one- or few-seeded. The seeds are pendulous, more or less compressed and oblong, or if solitary globose, two- to three-furrowed on the back, with a membranous or coriaceous testa. Endosperm is copious, cartilaginous, and in many cases ruminated. The embryo is axile, and straight, oblique or slightly curved, and half the length of the endosperm or longer. The cotyledons are foliaceous and much wider than the superior cylindrical radicle.

Seedlings.—The cotyledons of Diospyros Embryopteris (fig. 508) are lanceolate-oblong, entire, trinerved, the nerves giving off short branches. The first pair of leaves are opposite, obovate-oblong, with a closely anastomosing venation. The ultimate leaves are lanceolate-oblong, coriaceous, entire, with ascending slightly incurved venation. In an unnamed species of Diospyros the cotyledons are ovate, trinerved from a little above the base, and 2–5 cm. long exclusive of the short petiole. The first twelve internodes of the stem are short, after which the primary axis becomes arrested and branches are developed horizontally from axillary buds a little below the apex which bears minute scale-like leaves. Previous to this ten ovate leaves are produced with incurved venation.

Diospyros Embryopteris, *Pers.* (fig. 508).

Hypocotyl erect, subcompressed, but possibly accidentally, longitudinally ridged and furrowed, glabrous, straw-coloured, about 4 cm. above the soil.

Cotyledons lanceolate-oblong, obtuse, entire, narrowed somewhat to the base and sessile, glabrous, three- or faintly five- to seven-nerved with slightly branching nerves, thin, 1·9–2·2 cm. long, 6–7·5 mm. wide.

Stem erect, subcompressed, densely covered with ascending pale brown hairs, ultimately woody; 1st internode 9 mm. long.

Leaves simple, entire, cauline, opposite in the seedling stage, ultimately alternate, exstipulate, petiolate, alternately and ascendingly penninerved, much reticulated, glabrous above, ciliate at the margin, and thinly covered beneath with adpressed hairs, coriaceous, evergreen; petioles very short, semiterete, flattened and shallowly grooved or channelled above, densely hairy in the seedling but less in the adult plant or glabrescent.

First pair obovate-oblong, obtuse, narrowed towards the base.

Ultimate leaves lanceolate-oblong, subacuminate, obtuse, shortly petiolate, subundulate at the margin, coriaceous, alternately and sharply ascendingly penninerved, very reticulate, glabrous above, thinly covered with adpressed hairs beneath or glabrescent, shining on both surfaces, deep green above, lighter green with a few large glands beneath.

Diospyros sp.

Hypocotyl woody, erect, terete, pubescent, soon becoming brown or almost black, 3·8 cm. or more above soil.

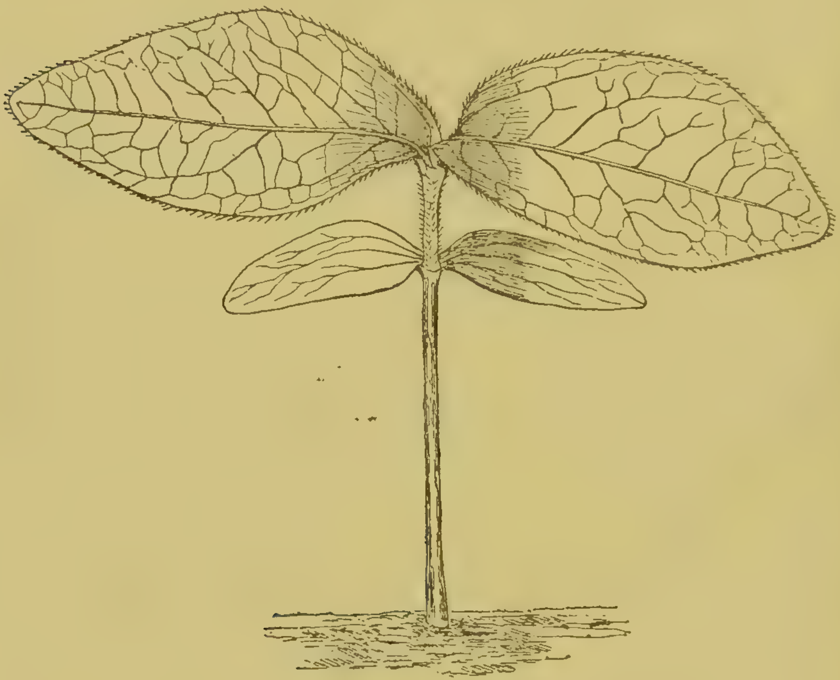

Fig. 508.—*Diospyros Embryopteris.* Nat. size.

Cotyledons large, foliaceous, ovate, obtuse, trinerved, shortly petiolate, coriaceous, thin, pubescent on the midrib above, otherwise glabrous, deep green above, much paler beneath; lamina 2–5 cm. long, 1·6 cm. wide; petiole grooved and pubescent above with a prominent mibrib, shallowly convex on the back, 2 mm. long.

Stem woody, erect, terete, densely pubescent, pale green, soon becoming arrested and producing long, lateral, horizontal or slightly ascending, flexuose branches; 1st internode 1·5 mm. long; 2nd 1 mm.; 3rd 4·25 mm.; 4th to 7th inclusive 3·5 mm.; 8th 3 mm.; 9th 4 mm.; 10th 1·5 mm.; 11th and 12th undeveloped. Here growth becomes arrested in this specimen, and a branch is produced in the axil of the ninth and tenth leaf respectively.

Leaves alternate and scattered on the stem, alternate and distichous on the branches, alternately penninerved with ascending nerves, ciliate, pubescent, dull green above, paler beneath ; petioles very short, 1–1·5 mm. long, flattened or slightly grooved above, densely pubescent.

Nos. 1–10. Small, ovate, obtuse, much smaller than the cotyledons.

Nos. 11 and 12. Minute and scale-like.

Lower branch leaves small, obtuse ; upper ones larger, ovate-lanceolate, obtuse.

STYRACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 666.

Fruit and Seed.—The ovary is inferior, or half, or wholly superior, consisting of two to five carpels cohering to form an ovary with as many cells, or the septa may become torn away from the axis while the plants are yet in flower, making one cavity. The ovules are solitary or few in each cell, attached to axile placentas, erect or pendulous and anatropous. The fruit is often baccate or drupaceous, and one-seeded by abortion, or it may contain from two to four seeds in one cell. In some cases the pericarp becomes hardened and ultimately splits open by three valves as in some species of Styrax. The testa of the seed is membranous or coriaceous, with frequently a broad hilum. Endosperm is more or less copious and fleshy or almost horny. The embryo is axile and straight, or more or less curved in some species of Symplocos, nearly equalling the endosperm in length, with the two cotyledons linear, plano-convex or together forming a terete body, or broad and flat with a short or elongated radicle.

The fruit of Halesia hispida is inferior and dry when mature, one- to three-celled and one- to three-seeded and indehiscent. The seeds are pendulous, with a large straight embryo, with oblong cotyledons rather narrower than the endosperm, plano-convex and somewhat flattened. The radicle is terete and slightly longer, but narrower than the cotyledons. In Symplocos paniculata (fig. 509) the seed is reniform and the embryo curved in conformity with it. The cotyledons are linear and not broader than the radicle. Only ten out of one hundred and sixty species have the seed and embryo so decidedly curved as in this instance. The fruit of Styrax is almost or wholly superior, and three-celled with a few seeds in each cell, attached near the base of the axile placentas. It is subdrupaceous and globose, but when mature may readily be split into three valves. It becomes one-celled and one-seeded, however, at an early stage by abortion. The seed is large, and globose with a thick crustaceous or woody testa. The embryo is straight and nearly equals the length and width of the endosperm. The cotyledons are broadly ovate, five-nerved and reticulate, somewhat longer than the terete radicle and several times wider.

Seedlings.—Few of these have been observed, but the character of the seedling may generally be surmised from that of the seeds. Two very distinct types at least may be noticed. The embryo is terete and straight or curved in Symplocos and the endocarp is frequently lignified. This is the case in S. paniculata (fig. 509), and the germinating embryo has to make its exit through a small round hole at one end of the endocarp. The cotyledons are slightly unequal in length, owing to their being strongly curved in conformity with the seed, and they are also narrowly linear, owing to its narrowness. This shape is also necessary in order to permit of their escape from the endocarp and seed. The leaves are alternate and the first two are elliptic and distantly serrate.

The cotyledons of Styrax japonica are foliaceous, broadly oblong-oval or elliptic, and trinerved, with all the nerves branching upwards similar to those of the leaves. The first three leaves are ovate-lanceolate, and distantly serrated on the margins.

Symplocos paniculata, *Wall.* (fig. 509).

Primary root of great length, with a few rootlets only in the young stage near the base.

Hypocotyl erect, terete, glabrous, pale green, arched at the top in germination, ultimately 2–2·7 cm. long.

Cotyledons unequal in length, linear, obtuse, sessile and slightly connate at the base, glabrous with a channelled midrib above, and slightly convex on the back; the longer 8–9·5 mm. long; the shorter 7–8 mm. long; both 1–1·25 mm. wide.

The endocarp of the fruit is obovoid, woody, and does not burst during germination. The radicle emerges by a small hole at the narrow end, the hypocotyl elongates, becoming curved and finally straightening, carrying up with it the endocarp containing the seed. As the cotyledons elongate they push out at the small hole in the endocarp, and finally get free and spread out to the light.

The cotyledons owe their shape to that of the seed which is reniform or curved, and contains a large quantity of fleshy endosperm. If a seed is cut open during germination the cotyledons are found to be linear, obtuse and, together with the apex of the hypocotyl, curved like the head of a shepherd's staff. Their shape then might be accounted for by the shape of the seed, the quantity of endosperm originally surrounding them, and thirdly by the difficulty that broad cotyledons would experience in getting out of the indehiscent endocarp.

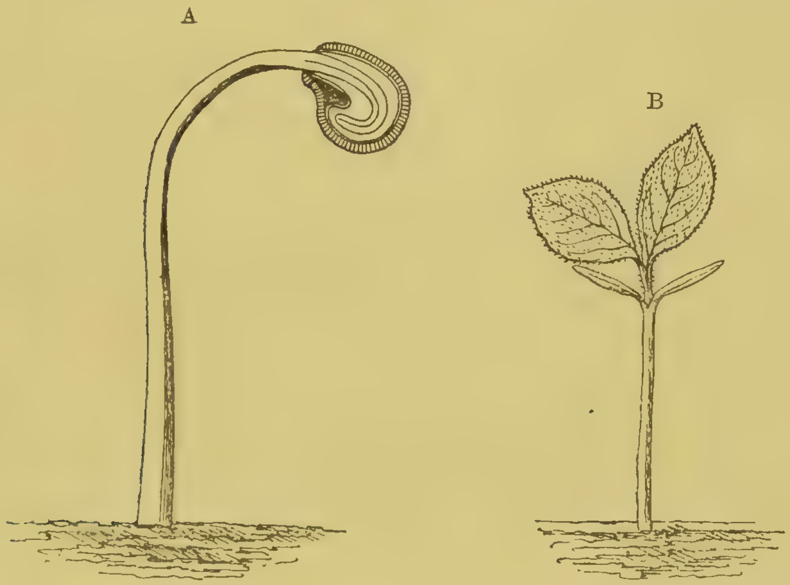

Fig. 509.—*Symplocos paniculata.* A, germinating seedling with vertical section of endocarp and seed, showing mode of exit of embryo, × 2. B, seedling (nat. size).

Stem erect, terete, hairy with upwardly incurving colourless hairs; 1st internode 2–4 mm. long; 2nd much shorter.

Leaves simple, alternate, exstipulate, very shortly petiolate, penninerved with ascending, incurved nerves, hairy on both surfaces.

Nos. 1 and 2. Elliptic, acute, shallowly and distantly serrate above the middle, tapering at the base, decurrent and forming a narrow wing to the short petiole.

Halesia hispida, *Benth. et Hook.*

Pistil syncarpous, inferior ; ovary of three carpels, three-celled, many-ovuled ; ovules seated on the middle of the placenta with the superior ones ascending, and the lower ones pendulous, anatropous ; micropyle inferior and superior accordingly.

Fruit subfleshy when young, becoming dry when mature, indehiscent, crowned with the persistent calyx-teeth, densely covered with stiff, bristly, spreading, more or less brittle and easily detached hairs, one- to three-celled, one- to three-seeded by abortion ; when reduced to one or two, the seeds do not occupy the whole interior of the fruit. The pendulous anatropous ovules in the lower part of the ovary seem to be most often fertilised and to reach maturity. Endocarp hard and woody.

Seed oblong, slightly narrowed at either end, conforming to the interior of one cell, and often somewhat oblique to the longitudinal axis of the fruit ; testa comparatively thin, and much more so than the endocarp ; hilum and micropyle superior and contiguous in the pendulous seeds.

Endosperm copious, fleshy, white.

Embryo comparatively large, straight, embedded in and falling a little short of the endosperm, colourless ; cotyledons oblong, obtuse, entire, slightly narrowed towards the apex, plano-convex, and closely applied face to face, lying in the broader axis of the seeds when the latter are in any way compressed, with their backs to the axis ; radicle terete, obtuse, stout, somewhat longer than the cotyledons, and lying with its point close to the base of the endosperm.

Styrax officinale, *L.*

Pistil syncarpous, almost or wholly superior, fixed with a broad base to the receptacle ; ovary of three carpels, three-celled with each cell five-ovuled ; ovules basal, erect from the inner angles of the cells, anatropous ; micropyle inferior.

Fruit globose, splitting when mature into three valves, glabrous, fixed with a broadish base to the receptacle, and surrounded there by the calyx, one-celled at an early stage by the rupturing of the septa, one-seeded ; epicarp and endocarp subcoriaceous ; mesocarp fleshy.

Seed subglobose, slightly depressed and a little broader than deep, basal, erect, marked longitudinally or in a radiating manner from the hilum to the apex by three shallow furrows and three slender intermediate and equidistant ridges ending in a small elevated point, and all corresponding to their counterparts on the inner face and apex of the pericarp; testa very thick, crustaceous or almost horny or bony, pale brown and shining; tegmen thin, pale, membranous; hilum basal, depressed, pale-coloured, rather conspicuous; raphe and chalaza indiscernible in the mature seed.

Endosperm copious, fleshy, white when moist and becoming pale yellow, prominent at the micropyle and pushed a little way into the testa.

Embryo nearly as long as the endosperm, slightly curved, similar to the endosperm in colour; cotyledons broadly ovate, obtuse, entire, flat or nearly so, about equalling or slightly longer than the radicle and less in diameter, lying in the endosperm with their backs to the placenta, and somewhat transverse or obliquely transverse to the latter with five incurving nerves at the base, anastomosing towards the margin; radicle cylindrical, pointing to the micropyle, contiguous to and on one side of the hilum, its tip projecting into the projecting part of the endosperm, piercing the testa at the micropyle.

Styrax japonicum, *Sieb. et Zucc.*

Hypocotyl erect, terete, about 4 cm. long, with a few minute hairs, light green or colourless.

Cotyledons broadly oblong-oval, obtuse, entire, petiolate with short flat petioles, glabrous, dark green, distinctly pinnatinerved like the leaves.

Stem erect, terete, herbaceous, ultimately woody, hispid; 1st internode 1 cm. long; 2nd about 5–6 mm.

First leaves simple, cauline, alternate, exstipulate, shortly petiolate, lanceolate, acuminate, rather serrated on the edges, obtuse, hispid, distinctly pinnatinerved.

OLEACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 672.

Fruit and Seed.—The ovary is superior, of two carpels, syncarpous and two-celled. The ovules are usually geminate in each cell, rarely solitary or four to eight, attached to the base or the apex of the dissepiment and amphitropous or more often anatropous, with a superior micropyle when inserted at the apex of the septa. The fruit is capsular, dehiscing loculicidally by two valves, or baccate or drupaceous. The seeds vary from two to four, but are usually solitary by abortion in each cell, and erect or pendulous. The testa is usually membranous, rarely slightly thickened. Endosperm is usually abundant, and fleshy, hardened or somewhat horny, or oily; rarely is it entirely absent as in Schrebera or in some species of Linociera. The embryo is straight and axile with flat and ovate or oblong cotyledons when endosperm is present, and thick and fleshy ones when the latter is absent. The radicle is generally short and sometimes surrounded by the cotyledons, rarely elongated, and superior or inferior according to the insertion of the seed. A few exceptions to the above characters are met with in some species. A tricarpellary ovary sometimes occurs in Fontanesia and Nyctanthes. Endosperm is wanting as above mentioned in Schrebera, and the cotyledons are plano-convex but much twisted. The radicle is inferior and considerably elongated in Myxopyrum. The seed is pendulous and anatropous in Syringa vulgaris, and solitary by abortion in a capsular fruit. The embryo nearly equals the endosperm in length and has oblong flat cotyledons about twice the length of the radicle. The embryo is much shorter, and in fact scarcely half the length of the endosperm in the mature seed of Fraxinus excelsior (fig. 511), and the cotyledons are oblong or oblong-lanceolate, obtuse or entire with numerous alternate, incurved nerves uniting with one another within the margin. This latter character is best seen in the embryo (fig. 511) which is preparing for germination and has almost filled the seed. The latter is very much flattened laterally and fills the cavity of the seed-vessel which develops into a samaroid fruit with a wing at the apex in line with its longitudinal axis. The narrow septum becomes ruptured from the walls of the cells during growth and appears like a greatly elongated funicle in the mature fruit. Three out of four ovules become atrophied at an early age, and their remains may be seen close to the short true funicle.

The characters of the young ovary of Ligustrum japonicum are very similar to those of Fraxinus, but the ovules are inserted a little below the apex of the placenta.

The fruit, however, is globose and drupaceous, with a globular seed conforming to the interior of the cavity. The embryo is nearly as long as the endosperm, with orbicular cotyledons about equalling the slightly curved radicle.

Seedlings.—The shape of the cotyledons and their length have direct relation to the seeds from whence they are derived, but they may undergo some slight alteration during and after germination. They are enabled to increase greatly in size by feeding upon the endosperm before leaving the seed, and may also profit from the latter by storage of plastic material. At least three fairly distinct types have come under my notice, namely, ovate, oblong, and oval cotyledons.

Those of Forsythia suspensa (fig. 510) are ovate or oblong-ovate, emarginate and obscurely penninerved. The first pair of leaves are ovate and serrate. The majority of the adult leaves are ovate, but many pinnately trifoliolate ones occur on the same plant or even the same shoot bearing the more typical form. They are, therefore, rather strikingly dimorphic.

The second type, with oblong cotyledons, is met with in Fraxinus excelsior (fig. 512). The first pair of leaves are ovate and serrate, but the second pair are pinnately trifoliolate, while succeeding ones gradually acquire a greater number of leaflets making an imparipinnate leaf. The cotyledons of F. Sogdiana are broadly oblong and penninerved with a branching venation. The first pair of leaves are like those of F. excelsior, but the second pair are lanceolate-cuneate and serrated above the middle.

The cotyledons of Ligustrum japonicum represent the oval type, and the penninerved venation is similar to that of the leaves in the last case. The first pair of leaves are oblong-oval and obtuse; but the ultimate leaves are ovate or elliptic, more pointed and coriaceous. The seedling of L. robustum is similar in all important points to that of L. japonicum, but the cotyledons are perhaps more distinctly emarginate. The first two pairs of leaves are lanceolate-elliptic.

Forsythia suspensa, *Vahl* (fig. 510).

Primary root a perennial, woody, long taproot, with long, distant horizontal fibres, almost smooth.

Hypocotyl firm, 1·5–2 cm. long, 1 mm. thick, terete, glabrous, brown.

Cotyledons with swollen buds in their axils equal, 1·5–2 cm. long, 6–9 mm. wide, emarginate, oblong-ovate, cuneate at the base, concave, obscurely pinnatinerved, firm but not very thick, glabrous, dull yellowish-green.

Stem erect, terete, glabrous, ultimately woody, rough with lenticels.

Leaves simple or compound, serrate, cauline, opposite, exstipulate, petiolate, with alternate or sometimes subopposite, ascending nerves, glabrous, deep green above, paler or subglaucous beneath; petioles channelled above, semiterete, dilated at the base, and articulated with the stem.

The first and second pairs are broadly ovate, obtuse, serrate, and penninerved.

Ultimate leaves very variable on the same branch, and simple or compound often mixed even on vigorous branches; simple ones ovate or subcordate, acute, or in some instances rotund-ovate, obtuse; compound ones pinnately trifoliolate; terminal leaflet ovate, acute, cuneate at the base; lateral leaflets much smaller, elliptic, acute, unequal at the base, or obovate and obtuse or acute, variable.

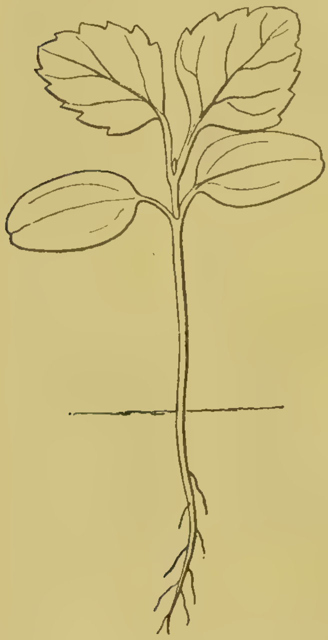

FIG. 510.
Forsythia suspensa.
Nat. size.

Syringa vulgaris, *L.*

Ovary two-celled, with one ovule in each cell; ovules anatropous; micropyle superior.

Fruit a two-celled capsule, dehiscing at the apex, one seed in each cell.

Seeds oblong, smooth, winged, laterally flattened, 8–10 mm. long; hilum inconspicuous, basal.

Endosperm copious, fleshy, white, surrounding the embryo.

Embryo straight, nearly equal in length to the endosperm, colourless; cotyledons oval, obtuse, entire, rather narrow, plano-convex; radicle terete, obtuse, slightly shorter than the cotyledons, close to the hilum and pointing to the upper end of the seed.

Fraxinus excelsior, *L.* (fig. 511).

Ovary two-celled, each cell two-ovuled; ovules pendulous from the top of the cells, anatropous; micropyle superior.

Fruit a samara, linear-oblong, obtuse, nearly always obliquely emarginate, laterally much compressed and thin, produced at the apex into a thin wing, glabrous, striated longitudinally with nerves, one-celled by the rupture of the septum, one-seeded by abortion, indehiscent; septum in the narrow way of the fruit, soon becoming ruptured and bearing at its apex three aborted ovules and one fertile seed.

Seed oblong, obtuse, slightly narrowed at both ends, much compressed laterally, thin, striated or shallowly furrowed longitudinally, deep brown, conforming in shape to the interior of the fruit, suspended from the apex of the septum or placenta by a curved funicle which is persistent; raphe dorsal, passing round the dorsal edge to the chalaza at the apex of the seed; micropyle and radicle superior.

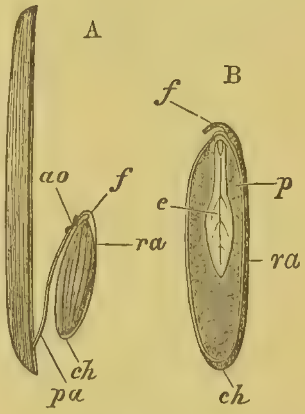

Fig. 511.—*Fraxinus excelsior.* A, samara with half removed and the seed pulled out (nat. size): *pa*, placental axis; *ao*, aborted ovules; *f*, funicle; *ra*, raphe; *ch*, chalaza. B, longitudinal section of seed, × 2: *f*, funicle; *p*, endosperm; *e*, embryo; *ra*, raphe; *ch*, chalaza.

Endosperm copious, fleshy, pale or colourless, and subtransparent.

Embryo straight, flat, comparatively small, embedded in the endosperm at the upper or basal end of the seed; cotyledons oblong, obtuse, entire, narrowed somewhat to the base, flat, closely adpressed, face to face; radicle stout, obtuse, somewhat shorter than the cotyledons, close to the micropyle at the upper end of the seed, but within the endosperm.

Seedling (fig. 512).

Primary root tapering downwards, with numerous flexuose, fibrous, lateral rootlets.

Hypocotyl erect, terete, glabrous, soon becoming woody and grey, variable in length, 4–6 cm. long or more.

Cotyledons oblong, obtuse, shortly petioled, entire, alternately but obscurely penninerved, with a distinct midrib, glabrous, variable in size; lamina 1·7–2 cm. long, 6–9 mm. wide.

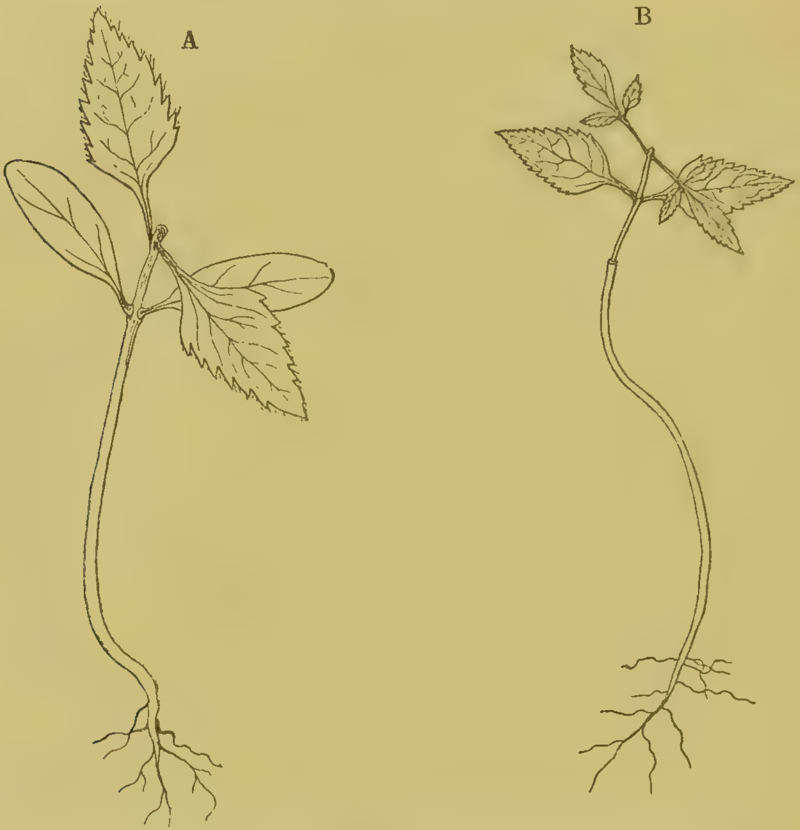

Fig. 512.—*Fraxinus excelsior.* A. Nat. size. B. An older seedling; the cotyledons have dropped. Two-thirds nat. size.

Stem woody, erect, terete, glabrous, pale green, becoming grey; 1st internode 6–10 mm. long; 2nd 6–8 mm.

Leaves compound (first simple), cauline, opposite, exstipulate, petiolate, minutely ciliate, ultimately glabrous at the margin, but in the leaves of the adult tree woolly at the junction of the lateral veins with the midrib beneath on the basal quarter of the leaflets, bright green and shining above, pale beneath and finely reticulate; petioles flattened above, dilated and thickened at the base, scarcely grooved.

First pair ovate, acute, serrate, simple, rarely lobed at the base.

Second pair pinnately trifoliolate; leaflets elliptic, acute, serrate above the middle, articulated with the rachis; terminal one largest.

Ultimate leaves imparipinnate, with three to five or more pairs of leaflets and a terminal one; lowest pair of leaflets lanceolate; terminal one lanceolate-elliptic; the rest oblong; all acuminate, with a narrow cartilaginous margin, rather distantly and unequally serrate, with acute serratures, hooked inwards at their tips, alternately penninerved, sessile, cuneate at the base; rachis narrowly channelled above, or margined, or winged, rounded on the back, much thickened at the insertion of the leaflets.

Fraxinus Sogdiana, *Bge.*

Hypocotyl erect, terete, glabrous, 1–2 cm. long, brown.

Cotyledons very similar to those of F. excelsior.

Stem erect, quadrangular, herbaceous, ultimately woody; 1st internode 7–10 mm. long; 2nd about the same.

First leaves simple, opposite, decussate, ovate or almost lanceolate, acute, coarsely serrate, glabrous, green, pinnatinerved; petioles rather short and broad, channelled on the upper face.

Olea cuspidata, *Wall.* (fig. 513).

Hypocotyl shrubby, erect, terete, glabrous, brownish, 1·2 cm. above the soil.

Cotyledons ovate, obtuse, entire, or usually slightly obliquely emarginate, penninerved, coriaceous, persistent, deep opaque green, paler beneath, glabrous, shortly petiolate; lamina 1·85 cm. long, 7·5 mm. wide; petiole channelled above, ·5–1 mm. long.

Stem shrubby, erect, terete, densely and shortly pubescent, greyish; 1st internode 8·5 mm. long; 2nd 5 mm.; 3rd 7 mm.; 4th 9·25 mm.; 5th 11 mm.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, shortly petiolate, scaly on both surfaces when young, ultimately glabrous or nearly so except the shortly ciliate margin, deep green and shining above, paler beneath, coriaceous, linear-lanceolate,

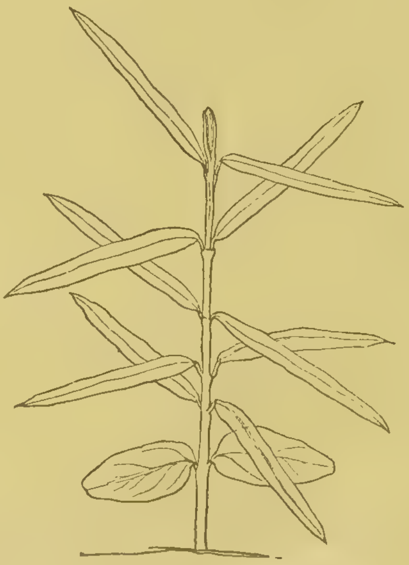

FIG. 513.—*Olea cuspidata.* Two-thirds nat. size.

acute or cuspidate, usually all similar in seedling stage, at any rate up to the sixth pair.

Olea cuspidata belongs to the type with ovate cotyledons, which closely resemble those of Forsythia suspensa. They are remarkable although by no means unique amongst the Phanerogamia in being broader than the first six pairs of leaves. Other instances of this relation of the cotyledons to the primary leaves may be found amongst the Cacteæ, Asclepiadeæ and Proteaceæ.

Ligustrum japonicum, *Thunb.*

Fruit a globose, one-seeded berry.

Seed obovate or globose, conforming in shape to the fruit, slightly flattened laterally, 3–4 mm. in diameter; hilum rather conspicuous; testa brownish.

Endosperm copious, surrounding the embryo, greyish-white or colourless.

Embryo straight, embedded in the endosperm, colourless; cotyledons suborbicular or oblong, obtuse, entire, closely adpressed; radicle, terete, obtuse, situated with its tip near the hilum.

Seedling.

Hypocotyl erect, terete, covered with very minute hairs, light green or almost colourless, 2–3 cm. long.

Cotyledons broadly oblong, obtuse, entire or minutely emarginate, petiolate, glabrous, light green, pinnatinerved like the leaves.

Stem erect, terete, covered with minute hairs, herbaceous, ultimately woody; 1st internode 6–10 mm. long.

First leaves simple, entire, cauline, opposite, shortly petiolate, exstipulate, oblong-oval, subacute, covered with minute hairs, light green, pinnatinerved.

APOCYNACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 681.

Fruit and Seed.—The ovary is superior and free, or more rarely half immersed in the receptacle, consisting of two carpels united by their edges, forming one cell with parietal placentas, or completely uniting to form axile placentas, while in a third type they are connate by their bases only or quite separate, with the placentas on the middle of the ventral suture. The ovules in each carpel are usually geminate or few and arranged in a double series, or indefinite and arranged in many series, very rarely solitary. They are frequently inserted by the ventral surface, peltate and amphitropous, or almost anatropous and pendulous, very seldom erect as in some species of Acokanthera and Vallesia. The fruit may consist of one undivided piece, and be indehiscent, fleshy or rarely dry and hard or samaroid; in many other cases the two carpels are merely united at the base or are entirely free, and the fruit is baccate, drupaceous and indehiscent, or follicular and dehiscing by the ventral suture, liberating the linear placentas. Rarely the fruit is united into one piece or the carpels dehisce by two valves. The seed is very variable in outline, and is sometimes peltate and sessile, but oftener more or less compressed with the ventral face flat or concave, and affixed to the placenta by the middle or higher up by a filiform funicle. The testa is membranous or subcoriaceous and occasionally produced into a wing, or develops at one or both ends into a tuft of long cottony hairs. The endosperm is fleshy or almost cartilaginous, but is often restricted to a thin layer and sometimes entirely absent. The embryo is large, straight, and almost equals the endosperm in length as well as width, with foliaceous and flat, concave, rarely convolute or twisted cotyledons. The radicle is terete and shorter, rarely longer than the cotyledons and superior, very rarely pointing to the base of the fruit. There are several exceptions to the general rule in the Order. Undivided and dehiscent fruits occur in Chilocarpus and Allamanda, with distinct carpels dehiscing by two valves in Aspidosperma. Endosperm is wanting in Aspidosperma, Willughbeia, Cerbera and allied genera, Leuconotis and Carpodinus; it is ruminated in Alyxia and in several other genera of the tribe Plumeriæ. The margins of the cotyledons are infolded in Adenium, folded together in Holarrhena, convolute in Wrightia, and much twisted in Kickxia. The radicle is inferior in Vallesia and some species of Rauwolfia. Acokanthera Thunbergii is notable for its baccate two-celled fruit, containing a large peltate seed in each cavity. The cotyledons of the embryo are foliaceous, roundly ovate and petiolate, about equalling the radicle and petioles in length.

Seedlings.—At least three or four different types of cotyledons may be observed amongst seedlings of this Order, and speaking generally they may be described as large and foliaceous, a fact to be accounted for by the large and flattened seeds and the great size of the embryo. The cotyledons of Thevetia neriifolia are suborbicular and compressed while yet in the seed, but they had dropped before the seedling was observed. The first ten leaves are linear-lanceolate and acuminate, longer and no doubt narrower than the cotyledons. A type with oblong, penninerved and reticulate cotyledons is met with in Echites umbellata (fig. 515). The first two pairs of leaves are ovate, larger than the cotyledons, but have a very similar venation. The cotyledons of Wrightia tinctoria are also oblong with a penninerved venation similar to that of the leaves, but they are unequal, a fact probably to be accounted for by their being convolute in the seed. The first five pairs of leaves are lanceolate, obtuse, larger and broader than the cotyledons. Parameria glandulifera represents a type with ovate cotyledons. The first three or four pairs of leaves are lanceolate-elliptic, acuminate. The first two or three pairs of Mandevilla suaveolens are lanceolate and narrower than the broadly ovate cotyledons which have a similar incurved venation. The ultimate leaves are oblong-cordate and finely acuminate.

The fourth type to be noted is represented by Plumeria alba (fig. 514) which has oblong-cordate, trinerved cotyledons, the basal auricles of which are frequently unequal. They attain this shape while yet in the seed. The first pair of leaves are oblong-lanceolate and opposite, followed by four others which are similar but larger, and alternate. The cotyledons of Tabernæmontana amygdalifolia differ from those of the last in being broadly triangular and subcordate at the base, with a venation similar to that of the leaves. The first two pairs of the latter are opposite, and broadly lanceolate or ovate.

Acokanthera Thunbergii, *Benth. et Hook.*

Ovary syncarpous, superior, two-celled, each cell one-ovuled; ovule ventrally attached, amphitropous; micropyle superior.

Fruit baccate, ellipsoid, glabrous, black when mature or suffused with a glaucous bloom, two-celled, two-seeded.

Seed oval in outline, concavo-convex, peltate, ventrally attached to the middle of the placenta, pale, subtransparent and whitish; testa closely adhering to the endosperm; radicle superior and close to the micropyle; hilum large, oval, occupying the greater part of the concave ventral face.

Endosperm abundant, pale subtransparent white, fleshy and tough or subcartilaginous and easily cut, occupying the greater part of the seed.

Embryo straight, thin, falling a little short of the length of the seed, and slightly curved or concave towards its inner base, and conforming to its dorsal convexity; cotyledons thin, closely adpressed face to face, rotund-ovate, obtuse, entire, occupying a median position in the seed, a little nearer the dorsal than the ventral aspect, surrounded by endosperm; radicle very short, but the radicle and petioles together are about 3–4·5 mm. long, and nearly or quite equal to the cotyledons in length.

Thevetia neriifolia, *Juss.*

Hypocotyl 2–3 cm. long, 3 mm. thick, terete, glabrous, woody, colourless.

Stem woody, glabrous, light green; 1st internode 5–6 cm. long, 2–2·5 mm. thick; 2nd 1 cm. long; 3rd to 10th much shorter.

Leaves simple, entire, cauline, alternate or the earlier ones nearly or quite opposite, exstipulate, shortly petiolate or subsessile, decussating in the seedling stage, subcoriaceous, glabrous, bright green.

Nos. 1 and 2. Nearly opposite, subsessile, 3–5 cm. long, 6·5 mm. wide, linear-lanceolate, acuminate, with a distinct articulation at the base, entire, penninerved, straight or slightly recurved at the apex, channelled, quite glabrous, bright green, somewhat leathery.

Nos. 3–6. Nearly opposite, linear-lanceolate, acuminate; the rest alternate.

Plumeria alba, *L.* (fig. 514).

Hypocotyl woody, erect, terete, fleshy, glabrous, pale green, shining, ultimately becoming grey, about 2·8 cm. above the soil. Juice milky.

Cotyledons large, foliaceous, broadly oblong-cordate, obtuse, shortly petiolate, with the basal auricles frequently unequal; lamina

1·7 cm. long, 1·05 cm. wide; petiole about 1 mm. long. Juice milky.

Stem woody, erect, terete, tapering upwards, glabrous, pale green becoming grey, fleshy, smooth or frequently warted, especially under the leaves; 1st internode 1·5 cm. long; 2nd 1·3 cm.; 3rd 9 mm.; 4th 1 cm. Juice milky.

Leaves simple, entire, cauline, alternate (1st and 2nd opposite), exstipulate, petiolate, glabrous, alternately penninerved, deep green above, paler beneath, shining on both surfaces; petioles convex on the back, flattened above or slightly channelled on each side of a prominent midrib, glabrous; midrib of leaf prominent on both surfaces. Juice milky.

Nos. 1 and 2. Opposite, oblong-lanceolate, obtuse, minutely apiculate.

No. 3. Lanceolate, acute, tapering to both ends.

Nos. 4–6. Narrowly oblong, acute, tapering at the base.

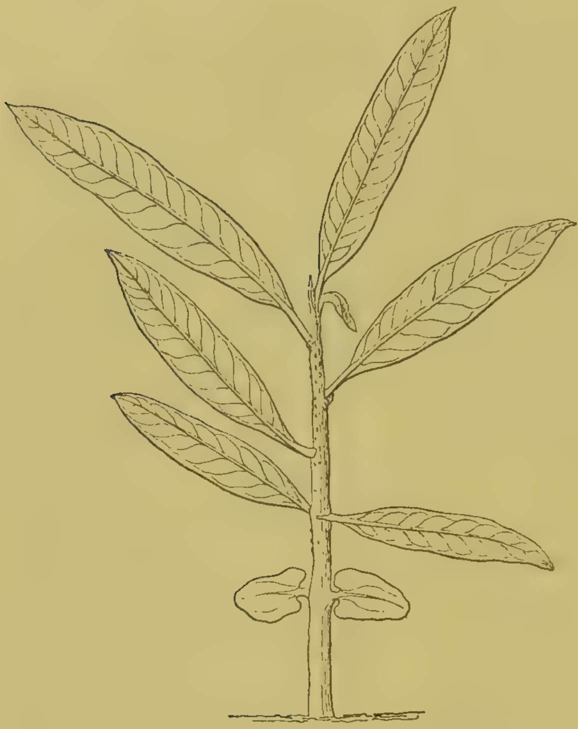

FIG. 514.—*Plumeria alba.* Half nat. size.

Tabernæmontana amygdalifolia, *Jacq.*

Hypocotyl erect, striated, scabrous, 5–6 cm. long, green.

Cotyledons broadly triangular or subcordate, obtuse, entire, somewhat wavy, petiolate, glabrous, green, distinctly pinnatinerved as are the leaves; petioles comparatively short, furrowed on the upper face.

Stem erect, striated, scabrous, herbaceous, ultimately woody; 1st internode about 3 cm. long; 2nd about 5 mm.

First leaves simple, entire, cauline, opposite, decussate, broadly lanceolate or ovate, almost acuminate, obtuse, petiolate, exstipulate, glabrous, green, paler beneath, distinctly pinnatinerved; petioles comparatively short, channelled on the upper face.

Wrightia tinctoria, *R. Br.*

Hypocotyl erect, terete, glabrous, woody, 3·5–4 cm. long, brownish.

Cotyledons unequal, membranous, oblong, obtuse, entire, petiolate, glabrous, green, distinctly pinnatinerved like the leaves.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 3·5 cm. long; 2nd about 3 cm.; 3rd rather shorter.

First leaves simple, entire, cauline, opposite, decussate, oblong-lanceolate, obtuse, petiolate, exstipulate, glabrous, green with a subglaucous hue above, pinnatinerved; petioles short, flat, slightly furrowed above.

Parameria glandulifera, *Benth.*

Hypocotyl woody, terete, pubescent, 1·7 cm. long, 2 mm. thick, pale ashy grey.

Cotyledons shortly petiolate, ovate, obtuse, entire, coriaceous, pale green, 1·6–2·2 cm. long.

Stem erect, terete, thickened at the nodes, 2 mm. thick, and gradually tapering upwards, shortly, finely and densely pubescent; 1st internode 4–8 mm. long; 2nd 1·5 cm.; 3rd 1·8 cm. In different specimens these lengths are variable.

Leaves simple, entire, cauline, opposite, decussate, shortly petiolate, subacuminate, obtuse, coriaceous, penninerved, pale green, shining, finely pubescent on the midrib beneath; petiole 3 mm. long, flattened above and convex beneath, finely and densely pubescent, apparently connate at the base and surrounding the stem, forming a transverse scar with small black, stipuliform teeth on its upper edge.

First pair falling early, even before the cotyledons.

Second to fourth pairs lanceolate-elliptic, acuminate, obtuse, finely penninerved.

Echites umbellata, *Jacq.* (fig. 515).

Hypocotyl erect, terete, slender, finely and minutely pubescent, about 8–10 mm. above the soil.

Cotyledons oblong, obtuse, entire, shortly petiolate, glabrous, coriaceous, alternately and ascendingly penninerved, with the nerves incurved and uniting at the tip, appearing somewhat reticulate, deep green above, with generally pinkish veins, paler beneath and often reddish, horizontal from ascending or suberect petioles; lamina 9·5–10·5 mm. long, 5–5·5 mm. wide; petiole semiterete, channelled above, slightly connate at the base, finely and minutely pubescent like the stem, dull purplish, about 1 mm. long.

Stem erect, terete, slender, almost filiform, ultimately woody and twining, finely and minutely pubescent when young, and purplish; 1st internode 4–4·5 mm. long; 2nd 1·45–1·6 cm.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, shortly petiolate, alternately incurvinerved and more or less reticulate, glabrous, coriaceous or subcoriaceous, deep green above, generally rather closely reticulated with red or pink, paler beneath and more or less suffused with pale red; petioles very short, semiterete, shallowly channelled above, finely and minutely pubescent, and reddish like the stem.

First pair ovate, obtuse, slightly cordate at the base, or almost rounded.

Second pair ovate, more elongated and somewhat more pointed.

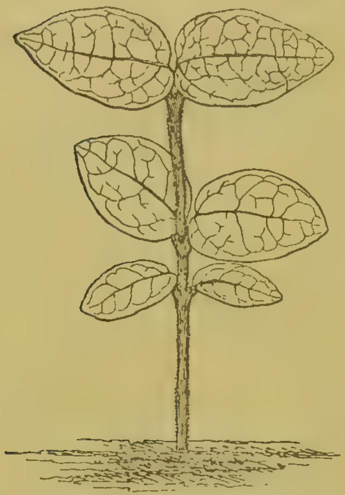

Fig. 515.—*Echites umbellata.* Nat. size.

Mandevilla suaveolens, *Lindl.*

Primary root fleshy, tapering, flexuose, colourless, and giving off lateral rootlets freely.

Hypocotyl erect or frequently flexuose, pale green, finely and minutely pubescent, 3–4·2 cm. long.

Cotyledons foliaceous, ovate, obtuse, alternately penninerved, reticulate, bright green and shining above, paler and shining beneath, finely pubescent on the petiole and midrib beneath and at the margin, otherwise glabrous; lamina 2·2 cm. long, 1·2 cm. wide; petiole erect, channelled above, 5 mm. long.

Stem erect and soft, ultimately twining and woody, minutely and closely pubescent, pale green; 1st internode 1·8 cm. long.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, minutely and finely pubescent on the petioles, the under sides of the midrib especially at the forkings of the veins and at the base of the leaf and at the margins, otherwise glabrous, alternately penninerved with ascending nerves slightly incurving at the tip, reticulate; petioles semiterete, shallowly channelled above, ultimately glabrous except in the channel, green or deeply stained with crimson.

First pair lanceolate, acute.

Second and probably the third pairs similar.

Ultimate leaves oblong-cordate, acuminate, acute.

ASCLEPIADEÆ.

Benth. et Hook. *Gen. Pl.* ii. 728.

Fruit and Seed.—The ovary is superior and consists of two distinct carpels, with their placentas on the ventral suture. The stigmas are however confluent into one. The ovules are numerous in each carpel, arranged in many series and imbricated, the uppermost being outermost, pendulous, anatropous, from a slightly prominent placenta. The fruit consists of two erect or widely spreading follicles, or one of them may be aborted, sessile, oblong, ovoid, or elongated, or fusiform, smooth, muricate, or many-winged, dehiscing by the ventral suture, often breaking away from the placentas. The seed is ovate, oval, oblong or elliptic, dorsally much compressed and often surrounded with a thin margin. The testa is membranous or coriaceous and often crowned with a long silky tuft of hairs as occurs in Apocynaceæ. Endosperm is present, usually copious and cartilaginous. The embryo is straight and axile, nearly equalling the endosperm in length with broad flat cotyledons and a short superior radicle. An exception to the above characters occurs in Atherandra where the ovary is half inferior. The terminal pencil of hairs is absent from the seeds of Finlaysonia and Sarcolobus (tropical Asia) and of Gonolobus stenopetalus (Mexico).[1]

The embryo of Periploca lævigata nearly equals the endosperm in length and has foliaceous, broadly oblong cotyledons. Several seeds examined contained two embryos. The seeds are surmounted by a coma which falls early. The same may be said of Stephanotis floribunda, the comose tuft of hairs of which is long, white and silky. The object of the coma is evidently for the distribution of the seed, but the thin and almost winged character of the latter renders the coma of less importance than it otherwise would be. The fruit consists of two very large fleshy follicles with exceedingly numerous seeds. The cotyledons are suborbicular.

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[1] A. Gray, *Proc. Amer. Acad.* xxi. 398.

Seedlings.—Oblong and ovate cotyledons predominate in this Order, but oval and subrotund ones are also met with. Those of Calotropis gigantea (fig. 518) are broadly oblong, obtuse, and entire, with an incurved venation similar to that of the first pair of leaves which are more elliptic in outline. Asclepias obtusifolia, Tylophora asthmatica, and Gymnolæma viride agree pretty closely with this type in having oblong, obtuse cotyledons with a venation resembling that of the primary leaves; they vary somewhat in width, but are always wider than the first pair of leaves. The first pair in Tylophora asthmatica are oblong-lanceolate, while the first five pairs of Gymnolæma viride are narrowly lanceolate and acute, or even acuminate. The cotyledons of Schubertia grandiflora are shortly oblong, obtuse, and of the same width as the ovate first pair of leaves.

A slightly different type of seedling is met with in Gomphocarpus campanulatus (fig. 517), which by its slender stems and long internodes shows a tendency to climb. The cotyledons are oblong with an incurved venation like that of the first three pairs of leaves which are ovate or subcordate and hairy. The cotyledons of a species of Microloma (fig. 516) are also oblong with incurved nerves, but they are notable for the great length of their petioles. The latter characteristic is due to the unusual shortening of the hypocotyl and probably to the nature of the situation in which the plant grows, necessitating the lengthening of the petioles in order to bring the lamina up to the light. The two first pairs of leaves are small and scale-like, while the succeeding three are linear-lanceolate with a few alternate, ascending, indistinct nerves on each side of the more evident midrib.

The ovate type of cotyledons is represented by Periploca lævigata where they are broader than the primary leaves with a similar venation. The first three pairs of leaves are ovate-elliptic. Some succulent types of seedlings have ovate cotyledons broader and larger than the leaves that follow them. Those of Sarcostemma brevistigma (fig. 519) are oblong-ovate and sessile. The first two pairs of leaves are ovate, but they are reduced to minute, scale-like organs. This plant like the species of Stapelia is notable for the stout fleshy character of the hypocotyl in its early stages. The seeds of Stapelia bufonia germinated in the remarkably short space of three or four days. The cotyledons are small, ovate, plano-convex, and after germination assume an ascending direction, placed obliquely to the axis or slightly twisted with the faces of the two turned in different directions. Those of Stapelia mutabilis and S. variegata (fig. 522) are similar and behave in the same way. The primary leaves of S. mutabilis are very small, conical, acute, opposite, decussate, very numerous on the short stem, and decurrent at the base, forming angles on the stem. The hypocotyl of S. variegata is remarkably large, clavate, fleshy, and compressed in a different plane from that of the cotyledons. The leaves are more shortly conical even than those of S. mutabilis, but are otherwise similar. The internodes of the young stem are slightly more elongated. Seedlings raised from seeds sent from Bangalore under the name of Hoya viridiflora (fig. 520) had broadly oval cotyledons with an incurved venation, and rather more numerous veins than in the first five pairs of leaves which are elliptic. Roundly oblong and emarginate cotyledons are met with in Stephanotis longiflora. The two first pairs of leaves are small and elliptic, followed by three pairs that differ only in being much larger. The cotyledons of a species of Ceropegia (fig. 521) from South Africa are roundly triangular and truncate at the base. The first four pairs of leaves vary from oblong to elliptic and are wavy at the margin.

Gymnolæma viride, *Benth.*

Hypocotyl erect, terete, glabrous, 1–1·7 cm. long, light green.

Cotyledons oblong, obtuse, entire, shortly petiolate, glabrous, dull green, pinnatinerved like the leaves; the nerves are raised on the upper side, giving them a wrinkled appearance.

Stem erect, terete, herbaceous, green, glabrous; 1st internode 8–13 mm. long; 2nd and 3rd 1·2–1·8 cm.

First leaves simple, entire, cauline, opposite, decussate, shortly petiolate, linear-lanceolate, acute, glabrous, light green, pinnatinerved, clothed with short silky hairs when young.

Periploca lævigata, *Ait.*

Seed triangular or plano-convex, obovate, considerably laterally flattened, about 5–6 mm. long; testa membranous, smooth, brownish, slightly winged at the edges and thickened near the hilum, comose; hilum rather conspicuous.

Endosperm surrounding the embryo, whitish-grey, and rather copious.

Embryo straight, embedded in the endosperm, yellowish-white; cotyledons broadly oblong, obtuse, entire, sessile, plano-convex, lying face to face in the broad way of the seed with their edges to the axis; radicle considerably shorter than the cotyledons. In two out of three seeds there were two embryos, the cotyledons lying obliquely in the broad way of the seed.

Seedling.

Hypocotyl erect, terete, covered with minute hairs, 1–2·5 cm. long, brownish-green.

Cotyledons ovate, subacute, entire, shortly petiolate, covered with minute hairs, dark green, pinnatinerved like the leaves.

Stem erect, terete, herbaceous, ultimately woody, covered with minute hairs; 1st internode 1–1·5 cm. long; 2nd 1–1·2 cm.

First leaves simple, entire, cauline, opposite, decussate, ovate-elliptic, acute, shortly petiolate, exstipulate, ciliate, covered with minute hairs, dark green, pinnatinerved.

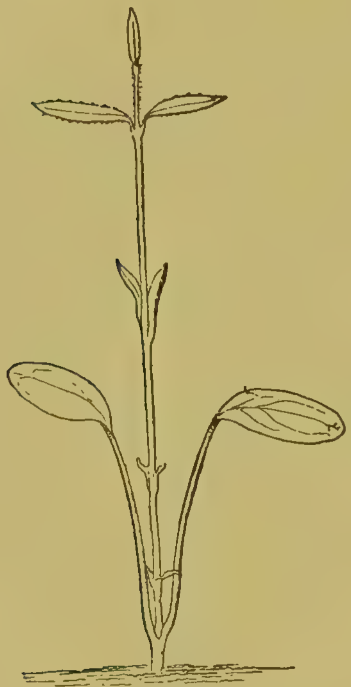

Fig. 516.—*Microloma sp.* One-third over nat. size.

Microloma sp. (fig. 516).

Hypocotyl erect, terete, very short, almost colourless.

Cotyledons oblong, obtuse, with long petioles, glabrous with a few alternate, ascending nerves, two of the larger of which curve round or inwards to the midrib near the apex, deep green; lamina 9–10 mm. long, 3·5–4 mm. wide; petiole semiterete, slender, slightly channelled above, about 1·85 cm. long.

Stem erect, terete, pale green, pubescent, ultimately twining and subshrubby; 1st internode 5 mm. long; 2nd 8·5 mm.; 3rd 1·1 cm.; 4th 1·6 cm.

Leaves simple, entire cauline opposite, exstipulate, with short petioles, alternately and ascendingly penninerved, thinly hairy (at least when young); petioles very short, thinly hairy, semiterete, slightly channelled above.

First and second pairs very small, almost scale-like, but green, lanceolate, obtuse.

Third and fourth pairs much larger, but still narrower than the cotyledons, linear-lanceolate, acute, with a few alternate, ascending nerves.

Schubertia grandiflora, *Mart. et Zucc.*

Hypocotyl erect, terete, hoary, about 2 cm. long, light green or colourless.

Cotyledons entire, broadly ovate or oval, obtuse, dark green above, subglaucous beneath, petiolate with petioles 1 cm. long, glabrous, but the petioles slightly hoary, 1·5 cm. long, 1·25 mm. wide, with a prominent midrib from which ascend numerous veinlets; the venation is the same as in the primary leaves.

Stem herbaceous, erect, terete, slightly pubescent, pale green; 1st internode 1 cm. long; 2nd much shorter.

Leaves entire, cauline, simple, exstipulate, petiolate, ovate, acute, dark green above, lighter beneath, glabrous with minute hairs on the edges; midrib with numerous ascending veinlets.

Gomphocarpus campanulatus, *Harv.* (fig. 517).

Hypocotyl erect, terete, glabrous, pale green (herbaceous when sketched), 3–8 mm. above the soil.

Cotyledons oblong, obtuse, petiolate, glabrous, deep green above, shining; lamina 11 mm. long, 6·5 mm. wide; petiole glabrous, grooved above, convex on the back, 6·5 mm. long.

Stem herbaceous at least in the early stages, erect, terete, ultimately twining, hairy with patent hairs, pale green or suffused with pale purple; 1st and 2nd internodes each 5 cm. long.

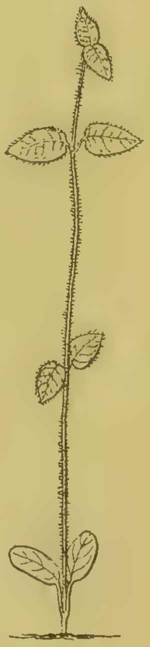

Fig. 517. *Gomphocarpus campanulatus.* Half nat. size.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, hairy on both surfaces, dull green above and dotted with the swollen bases of the hairs, pale green and shining beneath; petioles very short, semiterete, channelled on the upper side, hairy.

First three pairs small, ovate-subcordate, obtuse.

Calotropis gigantea, *R. Br.* (fig. 518).

Primary root long, flexuose, somewhat woody, with long, unbranched colourless fibres.

Hypocotyl firm, 3 cm. long, 1–2 mm. thick, terete, glabrous and whitish near the base, slightly tomentose, and bluish-brown above.

Cotyledons shortly petiolate, oblong, produced at the base and forming a channel on the petiole, rounded at the apex, entire, penninerved, glabrous, dull yellowish - green above, slightly paler and shining beneath, not very thick; petiole semiterete, channelled above, connate at the base.

Stem woody; 1st internode about 6 mm. long, slightly compressed, green, tomentose.

Leaves simple, entire, cauline, opposite, exstipulate, shortly petiolate, alternately incurvinerved, tomentose, greyish or hoary, subcoriaceous.

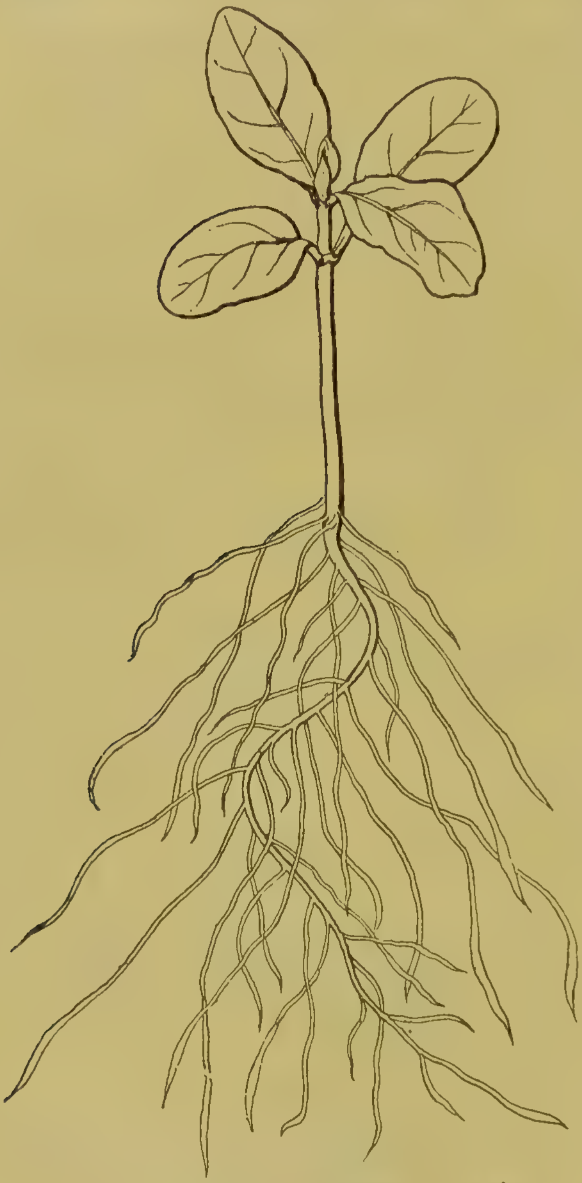

Fig. 518.—*Calotropis gigantea*. Nat. size

First pair elliptic, obtuse, entire, penninerved, subsessile, 2–2·5 cm. long, and 1–1·25 cm. wide, not very thick, slightly tomentose, dull greyish-green, slightly paler and shining beneath.

Asclepias obtusifolia, *Michx.*

Hypocotyl erect, terete, glabrous, 2·5–4·5 cm. long, light green tinged with red.

Cotyledons broadly oblong, obtuse, entire, petiolate, glabrous, green, pinnatinerved as in the leaves.

Stem erect, terete, herbaceous, covered with minute hairs; 1st internode 1–1·2 cm. long.

First leaves simple, entire, cauline, opposite, oblong, obtuse, shortly petiolate or subsessile, exstipulate, covered with minute hairs, light green, pinnatinerved.

Sarcostemma brevistigma, *Wight et Arn.* (fig. 519).

Hypocotyl erect, thickening upwards, glabrous or with a few scattered hairs, glaucous-green and dotted all over with very minute colourless markings, 2–2·5 cm. long.

Cotyledons oblong-ovate, obtuse, entire, subfleshy, glabrous, deep shining green above, paler beneath, with an indistinct midrib, sessile, 5–5·5 mm. long, 2·5–2·75 mm. wide, caducous.

Stem erect in the seedling stage, terete, slightly downy, glaucous-green, dotted with minute colourless markings, ultimately shrubby, scandent or procumbent; 1st internode 1·3–2 cm. long; 2nd 1·2–1·7 cm.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, sessile, all reduced to ovate or subulate, acuminate scales so small as to give the stems a leafless appearance.

Nos. 1 and 2. Ovate, minute, with an acute or acuminate, slender tip, pale green, slightly downy with a brown tip.

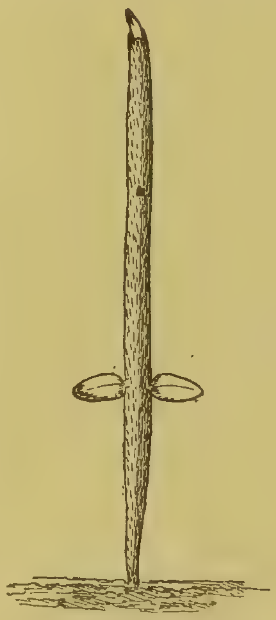

Fig. 519.—*Sarcostemma brevistigma.* Nat. size.

Stephanotis floribunda, *A. Brongn.*

Fruit very thick, fleshy, oblong, obtuse, many-seeded, consisting of one to two follicles.

Seed much compressed dorso-ventrally, flat, winged, comose, oblong-obovate, retuse at the base where the coma is attached, this consists of exceedingly numerous, long, white, silky hairs; hilum minute on the base of the ventral aspect; raphe ventral and passing along more than half the length of the seed; micropyle superior; wing narrow.

Endosperm copious and fleshy, surrounding the embryo.

Embryo straight, flat, large, colourless, nearly as long as the endosperm; cotyledons flat, broadly oval or suborbicular, central, entire; radicle cylindrical, obtuse, about one-half to two-thirds as long as cotyledons, close to the apex of the endosperm, pointing to, but some little distance from the hilum.

Stephanotis longiflora, ? *Hort.*

Hypocotyl woody, erect, terete, finely pubescent, pale green, about 7–10 mm. above the soil.

Cotyledons foliaceous, rotund-oblong, emarginate, rigid, coriaceous, glabrous, shortly petiolate, pale green and shining above, paler beneath; lamina 1·1 cm. long, 1 cm. wide; petiole slightly grooved above, 1 mm. long.

Stem woody, erect in the seedling stage, terete or slightly flattened in the opposite way to the leaves, finely pubescent, shining, green or subglaucous-green; 1st internode 4·5 mm. long; 2nd 4·25 mm.; 3rd 1·5 cm.; 4th 1·95 cm.; 5th 3·65 cm.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, petiolate, glabrous, thick, rigid or coriaceous, alternately and obscurely penninerved, even and shining on both surfaces, with the midrib slightly prominent beneath, and a pale hyaline or pink cartilaginous margin; petioles short, stout, slightly grooved above, rounded on the back and thickened at the base.

First pair elliptic, obtuse.
Second pair larger, subacute.
Third pair much larger, elliptic, acute.
Fourth pair small, unequal in size, acute.
Fifth pair large, elliptic, acute.

Hoya viridiflora, *R. Br.*? (fig. 520).

Hypocotyl erect, terete, glabrous, pale green, 6–12 mm. above the soil.

Cotyledons foliaceous, broadly oblong or oval, rounded at the apex, tapered to the base, petiolate, alternately and ascendingly penninerved with the tips only incurved and uniting with those next above them, shortly pubescent on the midrib above, otherwise glabrous, thin and membranous, light green above, and marked with pale-coloured dots; lamina about 1·8 cm. long, 1·2 cm. wide; petiole grooved above, convex on the back, dilating upwards, 6·5–7 mm. long.

Stem erect, terete, pubescent with curved hairs, pale green, soon becoming almost colourless, ultimately climbing; 1st internode 3·5–3·8 cm. long; 2nd 2–2·4 cm.; 3rd 1·8–2·2 cm.

Leaves simple, entire, cauline, opposite, decussate, stipulate, petiolate, alternately and ascendingly incurvinerved with the principal nerves giving off numerous anastomosing branches, thin and subcoriaceous in the seedling stage, thinly pubescent on the nerves on both surfaces with curved hairs, but denser towards and on the margin, deep green above, paler beneath; petiole semiterete, channelled above, pubescent on the edges and back with curved hairs; stipules minute, glandular, subulate, soon becoming brown and scarious, deciduous.

First to fifth pairs elliptic, obtuse, the upper ones shortly acuminate and more elongated or tapered to each end.

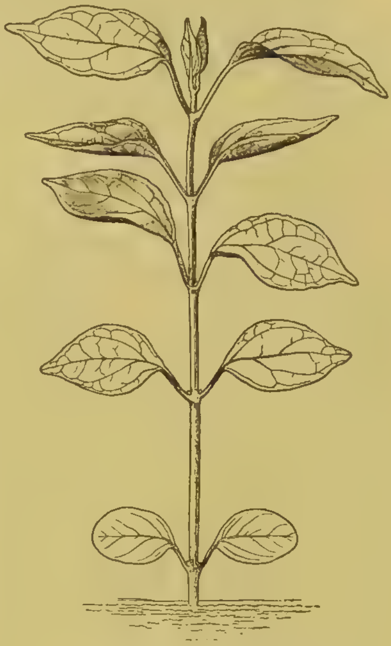

Fig. 520.—*Hoya viridiflora.* Half nat. size.

Ceropegia sp. (fig. 521).

Hypocotyl succulent, scarcely 1 cm. above ground, 3–4 mm. thick, slightly compressed, glabrous, pale green.

Cotyledons subsessile, nearly equal, about 1 cm. long and wide, and 1–2 mm. thick, roundly triangular or almost orbicular, with a truncate base and very obtuse apex, entire, nearly flat, marginate, obscurely nerved, succulent, glabrous, glossy green.

Stem succulent, suberect, terete, half as thick as the hypocotyl in the young stage, minutely verrucose, dark green.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, very shortly petiolate or subsessile, succulent, glabrous, with a midrib but an otherwise indistinct venation, green more or less suffused with a purplish tint.

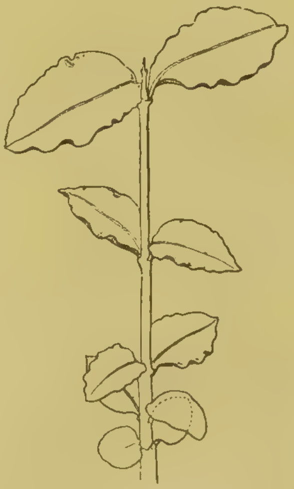

Fig. 521.—*Ceropegia sp.* Half nat. size.

First pair oblong, cuneate at the base, obtuse, glabrous with a sunk midrib, shortly petiolate, about 2 cm. long, and 1·5 cm. wide, succulent, purplish on both surfaces.

Second pair ovate, acuminate, with short, broad petioles, differing also from the first in the undulated margin and the silvery nerves and veins.

Third and subsequent pairs more lanceolate-ovate and much larger; fourth pair about 3·5 cm. long and 1·5 cm. wide.

Stapelia variegata, *L.* (fig. 522).

Hypocotyl erect, clavate, succulent, compressed the opposite way to the cotyledons, glabrous, pale subglaucous-green, 1·7 cm. above the soil.

Cotyledons ovate, obtuse, twisted obliquely and each facing an opposite way, ascending, coloured like the petiole, 3·5 mm. long, 2·5 mm. wide, sessile, persistent.

Stem succulent, erect, obtusely quadrangular by the decurrent bases of the leaves, glabrous, coloured like the hypocotyl; 1st internode 6 mm. long; 2nd 4 mm.; 3rd 3·5 mm.

Leaves succulent, simple, entire, small, cauline, opposite, decussate, exstipulate, sessile, coloured like the stem, shortly conical, acute, decurrent at the base, forming angles on the stem, horizontal, 1·5–1·75 mm. long.

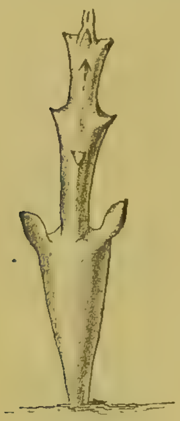

Fig. 522.
Stapelia variegata.
Nat. size.

Stapelia bufonia, *Jacq.*

Seeds ovate or oval in outline, surrounded by a corky rim, germinating in three or four days.

Primary root tapering, abundantly covered with root-hairs, colourless, rather stout.

Hypocotyl as in S. variegata, 2·05 cm. long, 3 mm. wide on the flattened faces, and 2 mm. on the narrow.

Cotyledons ovate, obtuse, sessile, plano-convex, and applied to each other obliquely in the seed by their flattened faces, which afterwards remain in an oblique position, each facing a different direction, 3 mm. long, 1·5 mm. wide, persistent.

Stapelia mutabilis, *Jacq.*

Hypocotyl as in S. variegata, 1·15 cm. above the soil.

Cotyledons as in S. bufonia, horizontal or placed obliquely, each facing a different way, pale subglaucous-green faintly mottled with paler markings, 2 mm. long, 1·25 mm. wide.

Stem as in S. variegata, pale glaucous-green mottled with minute paler markings; 1st internode 4 mm. long; 2nd to 8th inclusive each about 2–2·5 mm.

Leaves as in S. variegata, but longer and more acute, and tipped with a cartilaginous point; 2·5 mm. long.

GENTIANEÆ.

Benth. et Hook. *Gen. Pl.* ii. 799.

Fruit and Seed.—The ovary is superior, syncarpous, consisting of two carpels generally uniting by their edges so as to form one cell, with two parietal single or double placentas which are slender or prominent and project into the cavity; sometimes the margins of the carpels project into the centre of the ovary, forming two cells with axile placentas, as in the tribe Exaceæ. The ovules are generally numerous in each cavity or on each placenta, and arranged in one or more series, anatropous or amphitropous. The fruit is a thin or hard, rarely a fleshy capsule, dehiscing in most cases by two valves at the sutures, rarely bursting irregularly. Sometimes the whole inner surface is placentiferous. The seed is globose or angled, rarely compressed. The testa is membranous or crustaceous, smooth or rugose, and sometimes produced into a marginal wing all round, or at the base and apex only. Endosperm is copious, surrounding a small and short embryo, the radicle of which is superior or points in various directions according to the species.

Seedlings.—The most common form of the cotyledons in this Order is ovate, and they are small like the seeds. In Exacum bicolor (fig. 523), which may be given as a type, they are roundly ovate, petiolate, 3 mm. long and the same in width. The first pair of leaves is lanceolate-elliptic and trinerved, followed by two other pairs which are very much larger, with longer lateral nerves, but otherwise similar. The cotyledons of E. macranthum are broadly and roundly ovate, one-nerved, 3–5 mm. long, and 2–4 mm. wide. The first two pairs of leaves are broadly ovate, obtuse, and trinerved with the lateral ones incurved and joining the midrib close to the apex. The same type of cotyledon is seen in Gentiana verna (fig. 525), but the lamina is cuneate at the base and tapers into the petiole, which unites with its fellow and forms a little cup round the axis. The first five pairs of leaves are precisely like the cotyledons except in being slightly larger. In each case a midrib is the only apparent venation. The cotyledons of Swertia corymbosa are small, triangular-ovate and subtruncate at the base. Those of Erythræa pulchella are oblong-ovate and very small.

The seedling of Orphium frutescens (fig. 524) is remarkably distinct from any of the above. The cotyledons are shortly linear, without any apparent venation. The first five pairs of leaves are linear-spathulate and one-nerved, increasing in size from the first onwards. The primary internodes of the stem, which ultimately becomes shrubby, are elongated.

Exacum bicolor, *Roxb.* (fig. 523).

Hypocotyl erect, terete, glabrous, pale green, 1–3 mm. above the soil.

Cotyledons rotund-ovate, obtuse, petiolate, glabrous; lamina 3 mm. long, 3 mm. wide at the base; petiole channelled above, 1·5 mm. long.

Stem herbaceous, elongated when about to flower, glabrous, two-edged, pale green; 1st internode undeveloped; 2nd and 3rd each about 1·5 mm. long.

Leaves simple, entire, radical and cauline, opposite, exstipulate, petiolate, glabrous, shining on both surfaces, deep green above, paler beneath; petioles convex on the back, channelled on the upper side.

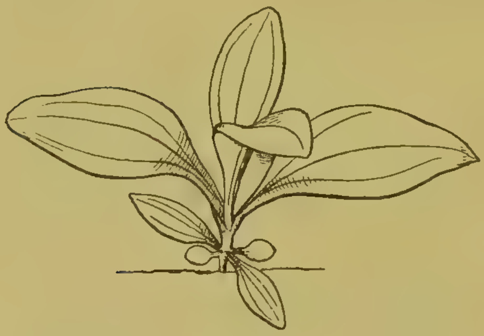

Fig. 523.—*Exacum bicolor.* Nat. size.

First pair small, lanceolate-elliptic, obtuse, trinerved at the base, tapering into the petiole.

Second and third pairs elliptic, obtuse, trinerved, tapering into the petiole.

Exacum macranthum, *Arn.*

Hypocotyl colourless, 2–3 mm. long, with a slight ridge.

Cotyledons very similar to those of E. bicolor.

Stem slightly ribbed; internodes of the seedling mostly of the same length, from 8–10 mm. long.

Primary leaves cauline, opposite, decussate, obtusely ovate, shining, green, trinerved, with a midrib and two lateral nerves parallel to the edges, and meeting at the apex.

Orphium frutescens, *E. Mey.* (fig. 524).

Hypocotyl erect, terete, glabrous, pale green, 4–11 mm. long.

Cotyledons shortly linear, obtuse, flattened above, convex on the back, sessile and slightly connate at the base, glabrous, deep green, shining when young, 5–6 mm. long, 1–1·25 mm. wide, frequently carrying up the seed on their tips during germination.

Stem erect, terete, light green when young, thinly pubescent, with a shallow furrow on alternate sides from where the edges of the leaves unite at their bases and seem to be decurrent on the stem down to the next node, ultimately shrubby; 1st internode 4–6·5 mm. long; 2nd 5–10·5 mm.; 3rd 1·3–2 cm.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, sessile, with an evident midrib but no other discernible venation, fleshy, deep shining green in the young state, thinly pubescent and densely marked all over with minute pale grey or colourless dots, tomentoso-pubescent or glabrous in the adult state, spreading, often curving upwards above the middle, and sometimes slightly twisted.

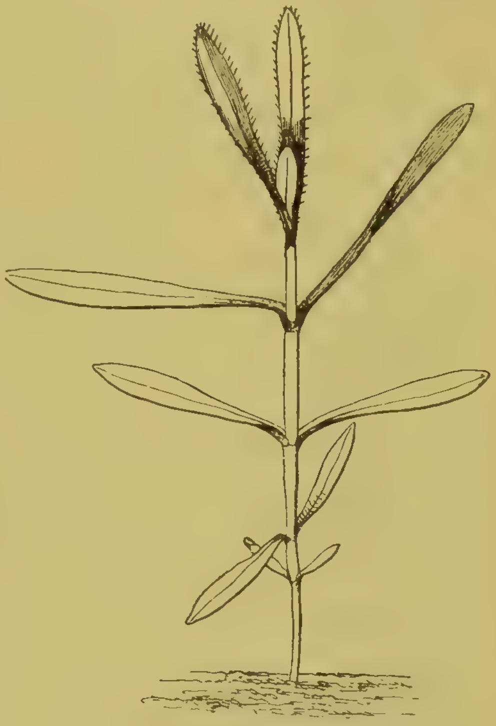
Fig. 524.—*Orphium frutescens.* Nat. size.

First pair linear-spathulate, suddenly tapered to a subacute tip.

Second to fifth pairs linear-spathulate, gradually longer, more obtuse, and the uppermost more decidedly linear, gradually tapering to a subclasping and very shortly connate base.

Ultimate leaves linear or oblong, thick and rather fleshy.

Erythræa pulchella, *Fr.*

Primary root short, fibrous, branched.

Hypocotyl erect, terete, glabrous, short and tapering indistinguishably into the radicle.

Cotyledons oblong-ovate, obtuse, entire, shortly petiolate, glabrous, very small, 1·5–2 mm. long including the petiole, and 1–1·25 mm. wide.

Stem herbaceous, angled, ridged and furrowed, glabrous; 1st and 2nd internodes undeveloped; 3rd 5–7 mm. long.

Leaves simple, entire, radical and cauline, opposite-decussate, exstipulate, sessile or the first pair shortly petiolate, glabrous, longitudinally nerved.

First pair spathulate, obtuse, shortly petiolate, one-nerved.

Second pair oblong-elliptic, trinerved, sessile.

Third pair obovate-oblong, trinerved, sessile.

Gentiana verna, *L.* (fig. 525).

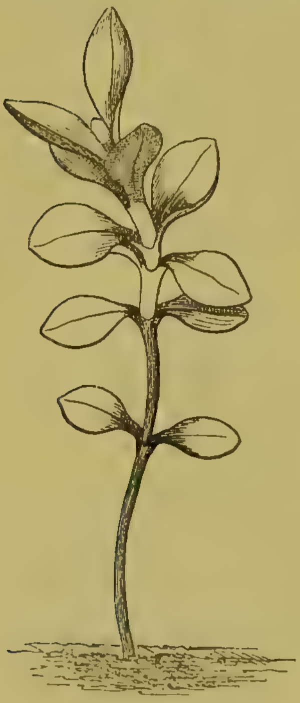

Fig. 525.
Gentiana verna, × 3.

Primary root slender, fibrous, perennial.

Hypocotyl erect or decumbent, terete, filiform, deep purplish-red, glabrous, 6–9 mm. long.

Cotyledons ovate, obtuse, entire, petiolate, showing a midrib but no other venation in a fresh state, glabrous, deep green, somewhat shining; lamina 1·75–2·25 mm. long, 1·5–1·75 mm. wide; petiole flattened above, convex on the back, green or with a red midrib, glabrous, connate at the base, about 1 mm. long.

Stem herbaceous, procumbent or creeping, and with ascending flowering shoots, terete, glabrous, pale green or reddish; 1st internode 2–4·5 mm. long; 2nd undeveloped or from ·5–2 mm.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, glabrous, deep green above, paler beneath, trinerved at least in the seedling, with the lateral nerves incurved and uniting with the midrib at the apex; petiole convex on the back, channelled above, connate and clasping at the base.

First to fifth pairs small, ovate, obtuse or, by tapering into the broadish petiole, subelliptic.

Swertia corymbosa, *Wight.*

Hypocotyl scarcely appearing above the soil.

Cotyledons triangular-ovate, obtuse, entire, subtruncate at the base, petiolate, glabrous, green, one-nerved; petioles short, flat, shallowly channelled above.

Stem erect, square, glabrous, herbaceous; 1st and 2nd (sometimes 3rd, 4th, 5th, and 6th) internodes undeveloped, later ones considerably elongated.

Leaves simple, entire, cauline or radical, decussate, exstipulate; radical ones on rather long petioles, the cauline, sessile; oval-oblong, obtuse, glabrous, green, trinerved; petioles flat, considerably channelled on the upper face.

First and second pairs ovate-elliptic.

Third to fifth pairs broadly oval.

POLEMONIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 820.

Fruit and Seed.—The ovary is superior and consists of three carpels united to form three cells with axile placentas; but a dimerous ovary occurs in some species of Collomia and other genera. There are two or more ovules in each cell, but they are rarely numerous, inserted by the middle on axile placentas and amphitropous. The fruit is capsular and dehisces loculicidally, rarely septicidally as in Cobæa scandens and other species of that genus. In these the placentas are flat and of great width and thickness; but in other cases the valves burst away carrying more or less of the septa and placentas on their middle. The seeds are ovoid, angled or dorsally flattened. The testa is sometimes developed into a wing at the margin, or in other cases covered with mucilage sometimes growing out into spiral tubes. The endosperm is copious and fleshy, or thick and cartilaginous or reduced to a very thin layer. The embryo is straight and axile, rarely one half shorter than the endosperm, with flat and generally rather broad cotyledons, and a short inferior radicle.

The three cells of the ovary of Collomia coccinea contain but a single ovule each, although other species have numerous ovules. The seeds are oblong, solitary and erect from the base of the inner angle of each cavity. The embryo occupies the greater part of the seed, and has thick, oval, plano-convex cotyledons and a well-developed radicle. Gilia laciniata is somewhat similar, but the seeds are very much smaller and the embryo relatively narrower with narrowly oblong, plano-convex cotyledons, considerably longer than the radicle. The ovules of Polemonium cæruleum are numerous, pendulous, and anatropous. The seeds are oblong and rather acutely trigonous by mutual pressure. The embryo almost equals the seed in length, but it is relatively very narrow, with linear-oblong cotyledons about the same length as the radicle. The ovules of Cobæa scandens are very numerous and arranged in a double series on each side of the middle line of the placental axis which is flattened with the placentas separated from one another but by no means prominent. The seeds (fig. 529) are the largest and most distinct of the Order observed; but they are exceptional rather than characteristic of the Polemoniaceæ. The fruit is a very large oblong capsule of three to four carpels with six to eight single placentas formed by separation of two that are usually united into one in other Orders. The seeds are large, oval or elliptic, much compressed dorsally, and nearly filled by a large embryo. The cotyledons are ovate-cordate, foliaceous and flat, with numerous incurved veins; and the terete radicle is very short.

Seedlings.—The cotyledons in this Order are all of simple types, and as a rule moderate in size. They vary from ovate to oval, spathulate and linear. In Polemonium cæruleum they are oblong-ovate. The first leaf is pinnate and trifoliolate; the second and third five-foliolate. The cotyledons of Collomia coccinea (fig. 526) are broadly ovate-oblong, generally minutely emarginate, with numerous alternate, ascending, incurved nerves, uniting in a submarginal line. The first pair of leaves are lanceolate-elliptic and entire; the second similar or with one to two teeth on each side. Cobæa scandens is very exceptional in the Order. The seeds are unusually large and so is the seedling. The cotyledons are large, foliaceous and ovate, subacute with a prominent midrib and primary lateral nerves. The first pair of leaves are opposite and imparipinnate with three pairs and an odd leaflet, all of which are oblong-lanceolate and penninerved. The second pair of leaves are opposite or slightly alternate, paripinnate and ending in a compound alternately branching tendril. They have each three pairs of leaflets. The fifth and sixth leaves are similar but alternate.

The seedling of Navarettia involucrata closely resembles that of Polemonium cæruleum, but the cotyledons are more oval, the first two leaves are quinquefoliolate, and the hypocotyl is more elongated.

The cotyledons of Gilia crassifolia (fig. 527) are spathulate with rather long petioles, dilated and connate at the base. The primary internodes being undeveloped a large number of the leaves are radical, and exhibit a considerable amount of evolution. The first pair are pinnatisect with five segments; the second pair have eleven to thirteen segments, and from the third pair onwards many of the primary ones are again divided at the base, making the leaves bipinnatisect. In Gilia lutea (fig. 528) belonging to the subsection Leptosiphon, the cotyledons are also spathulate but very small. The leaves also show a very distinct character in being palmately divided into linear segments, and being opposite they present a verticillate appearance. The first and second pairs are tripartite; the third pair have five segments, and the ultimate leaves are cut into seven to eleven linear diverging rays.

In Gilia squarrosa we have a seedling resembling that of G. crassifolia in habit, with a somewhat similar evolution of the leaves. The cotyledons are short and linear, and the first pair of leaves are like them but longer. The second pair have five segments; the third pair have five to seven segments; and the fourth pair are somewhat bipinnatisect with linear segments.

Collomia coccinea, *Lehm.*

Ovary of three carpels, surrounded at the base with a small annular disk, three-celled, with one ovule in each cell; ovule basal from the inner angle of the cell, erect, anatropous; micropyle inferior.

Fruit an obovoid-trigonous or trilobed capsule, glabrous, pale green, ultimately pale, colourless or dirty white, thin, brittle when dry, three-celled, three-seeded, dehiscing loculicidally, and also separating from the septa in three pieces, giving them the appearance of valves bearing the septa along their middle.

Seeds oblong, slightly compressed on the ventral aspect, solitary in each cell, erect, pale green, ultimately brown and slightly uneven; raphe ventral, somewhat shorter than the seed; hilum small, basal or slightly above the base on the ventral aspect; radicle at the extreme base, forming a slight prominence; testa consisting of somewhat pulpy adhesive matter when young, firm, brown and fibrous when mature.

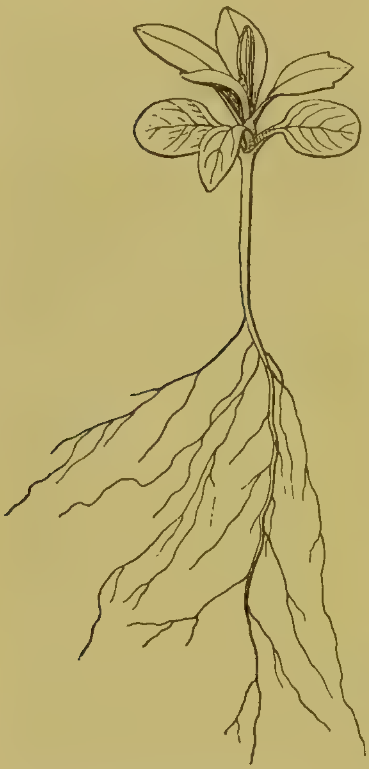

Fig. 526.—*Collomia coccinea.* Nat. size.

Endosperm scanty, fleshy, colourless or nearly transparent.

Embryo always straight in the axis of the fleshy endosperm, comparatively large and occupying the greater part of the interior of the seed and nearly as long, deep green, pale yellow when mature; cotyledons closely applied face to face, plano-convex, oblong or oval, obtuse, entire; radicle well developed.

Seedling (fig. 526).

Primary root long, tapering, with numerous lateral, flexuose fibres.

Hypocotyl erect, tapering downwards, pubescent, white beneath the soil, brown above, 6–14 mm. long.

Cotyledons oblong, obtuse, minutely emarginate, very slightly wider at the base, with a distinct midrib terminating in a water-gland, a colourless, cuneate mass of tissue sunk in the apex of the cotyledon and even with its surface. The midrib has many lateral, alternate, ascending nerves incurving towards their tip and uniting each with the next one above it, giving the appearance of two intramarginal nerves, and end finally like the midrib just beneath the water-gland. Tertiary nerves are given off along the anterior side of the secondary nerves and unite with the secondary nerve immediately above them. All this forms a perfectly continuous framework throughout the cotyledon, and in direct communication with the water-gland.

Around the apex of the leaf are numerous water-pores, seen from the upper surface, but better from beneath. A few are found a little way below the apex, but not so many nor so conspicuous as in Galium Aparine. The tissue immediately beneath the apex consists of polygonal cells with numerous small chlorophyll granules arranged round their sides, covered with wavy-outlined epidermal cells. The epidermal cells on the rest of the cotyledon are larger and very wavy, while the chlorophyll granules immediately beneath are very large and globose-ovoid, glabrous, deep opaque green above, paler beneath, subfleshy; lamina 8–10 mm. long, 6·5–7·5 mm. wide; petiole channelled above, glandular-pubescent, subperfoliate at the base, 4–5 mm. long.

Stem annual, branched, elongated when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate (lower ones opposite), exstipulate, petiolate, obscurely and alternately incurvinerved with the nerves uniting close to the margin, glandular-pubescent on both sides, deep opaque green above, paler beneath; petioles short, broad, channelled above, dilated at the base and subperfoliate in the opposite leaves.

First pair lanceolate-elliptic, entire, mucronate, obtuse.

Second pair lanceolate, subacute, mucronate, entire or having one to two teeth on each side.

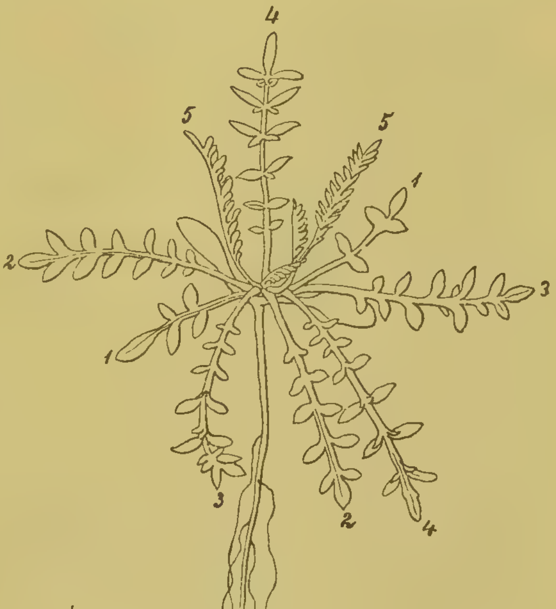

Fig. 527—*Gilia crassifolia*. Nat. size.

Gilia crassifolia, *Benth.* (fig. 527).

Primary root long, slender, tapering, with numerous lateral rootlets, annual.

Hypocotyl tapering downwards, colourless, subterranean and merging into the root.

Cotyledons spathulate, petiolate, glabrous; petiole flattened above, convex beneath, dilated and connate at the base, 6 mm. long;

lamina oblong, obtuse, tapering at the base, subfleshy, 6 mm. long, 3 mm. wide.

Stem annual, developed when about to flower.

Leaves simple, radical (and ultimately cauline), opposite, exstipulate, petiolate, glabrous except the petiole, deep green, subfleshy; petioles channelled above, ciliate on the upper edges, dilated at the base.

First pair oblong, pinnatisect with two lateral pairs and a terminal segment, all oval or oblong.

Second pair linear, pinnatisect with numerous oval segments; terminal one obovate.

Third pair linear, pinnatisect; segments small at the base, gradually lengthening towards the apex where they are oblanceolate; larger ones each with a segment on the posterior basal side.

Fourth and fifth pairs similar to the last, but rather longer and more equally developed.

Gilia squarrosa, *Hook. et Arn.*

Primary root as in G. crassifolia, colourless but with a few short lateral rootlets.

Hypocotyl as in G. crassifolia.

Cotyledons short, linear, obtuse, fleshy, glabrous, 6 mm. long.

Stem as in G. crassifolia.

Leaves simple, radical (and ultimately cauline), opposite, exstipulate, sessile, glandular-hairy, rather densely aggregated.

First pair linear, obtuse, fleshy, similar to the cotyledons but longer and glandular-hairy.

Second pair pinnatifid with two pairs of shortly linear, lateral segments above the middle.

Third pair similar, or with three pairs of segments.

Fourth pair linear-oblong in outline, with numerous alternate or subopposite, linear, slender, aristate segments.

Fifth pair more or less pinnatisect with pinnatifid segments; the ultimate segments or secondary lobes arise from the basal posterior side of the primary segments.

Gilia lutea, *Steud.* (fig. 528).

Primary root as in G. crassifolia, with small lateral rootlets.

Hypocotyl as in G. crassifolia.

Cotyledons small, spathulate, obtuse, rather fleshy, 5 mm. long including the petiole, glabrous.

Stem herbaceous, annual, erect, terete, slender, apparently branching dichotomously, sparsely and minutely pubescent and scabrous, pale green suffused with red; 1st internode 6 mm. long; 2nd 1 cm.; 3rd 9 mm.

Leaves simple, digitately or radiately tri- to multi-sect, cauline, opposite, exstipulate, sessile, deep green, subfleshy, minutely ciliate at the margin, otherwise glabrous.

First pair tripartite with acute segments; lateral segments linear; terminal one much larger, oblanceolate.

Second pair similar, but much larger.

Third pair five-sect; terminal segment oblanceolate; two lateral pairs slender, oblanceolate-linear.

Ultimate leaves seven- to eleven-rayed; segments linear; basal ones shortest and narrowest; all ending in a common subcuneate base.

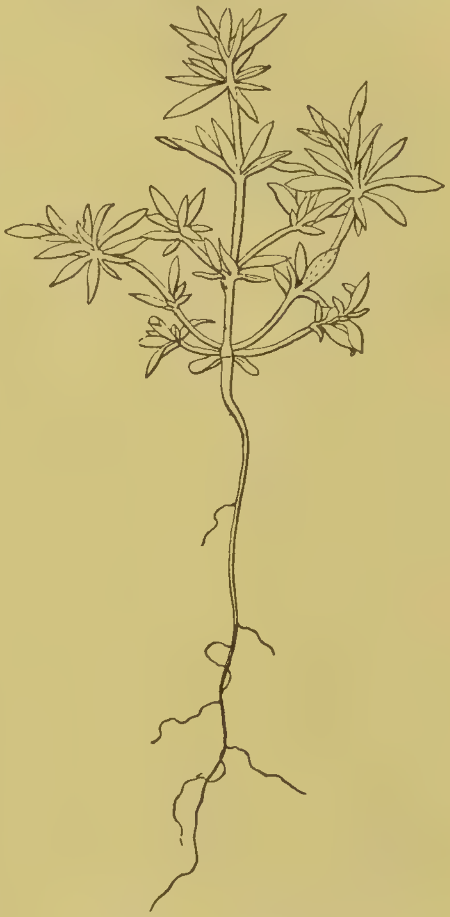

FIG. 528.—*Gilia lutea.* Nat. size.

Polemonium cæruleum, *L.*, *var.* album.

Primary root slender, tapering, colourless, giving off a few lateral rootlets.

Hypocotyl very short, tapering into the root, greenish-white.

Cotyledons petiolate; lamina oblong-ovate, obtuse, 7 mm. long, 4 mm. wide; petiole channelled above, 6 mm. long.

Stem ultimately stout and short, with very shortly developed internodes.

Leaves compound, imparipinnate, radical (and ultimately cauline), alternate, exstipulate, petiolate, glabrous, bright green above, paler beneath; petioles subterete, channelled above, dilated and subclasping at the very base.

No. 1. Pinnately trifoliolate; leaflets ovate; terminal one largest.

No. 2. Pinnately five-foliolate, otherwise like the first; pairs of leaflets frequently unequal.

Navarettia involucrata, *Ruiz et Pav.*

Hypocotyl erect, terete, glabrous, 2·5–4 cm. long, light green, colourless or stained with red.

Cotyledons oval, obtuse, entire, with very long petioles, glabrous or with a very few hairs on the petioles, green, rather distinctly pinnatinerved.

Stem erect, terete, herbaceous, glabrous, almost colourless or reddish; 1st internode 3–6 mm. long.

First leaves compound, pinnate; petioles long, with sometimes a few hairs, exstipulate; leaflets ovate, cuspidate, acute, sessile or shortly petiolate, opposite, glabrous or with a few hairs, light green, one-nerved.

Cobæa scandens, *Cav.* (fig. 529).

Ovary of three to four carpels, surrounded at the base by a large-lobed wavy disk, three- to four-celled, many-ovuled; ovules attached by the ventral aspect, ascending, amphitropous, arranged in two rows, one on each side the middle line of the placental axis and equidistant between that and the margin; micropyle inferior.

Capsule large, oblong, smooth, deep green and suffused with a glaucous bloom, ultimately brownish-yellow, three- to four-valved, three- to four-furrowed, dehiscing septicidally at the furrows; placental axis large, forming a triangular or sometimes quadrangular mass occupying the greater part of the interior.

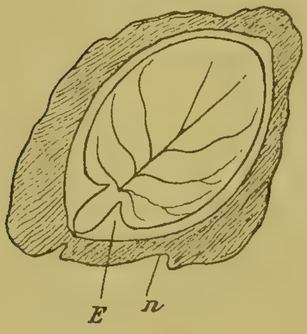

Fig. 529.—*Cobæa scandens.* Longitudinal section of seed in plane of cotyledons: *E*, endosperm; *n*, notch caused by hilum of another seed, × 2.

Seed large, much compressed dorsally, oval or subelliptic in outline or somewhat irregular, generally broader and always emarginate at the lower end, and narrowed to an obtuse point at the upper end, winged, brown, overlapping one another from the base upwards; radicle at the basal end; hilum ventral below the middle of the seed, spathulate in outline; raphe ventral, extending from the hilum to the inner edge of the wing; testa composed of slender fibrous material, mixed with pulpy matter when young.

Endosperm in young seed soft, dirty white, enveloping the embryo entirely, ultimately fleshy in the mature seed.

Embryo in the centre of the endosperm, straight from first to last, large occupying almost the entire length and breadth of the interior of the seed; cotyledons flat, rotund-cordate in the early state, ultimately ovate-cordate, obtuse, entire, alternately penninerved, colourless, but large, green and foliaceous after germination; radicle short, cylindrical, somewhat pointed.

Seedling.

Primary root normal, long, tapering, with lateral rootlets.

Hypocotyl becoming woody, erect, terete, glabrous, suffused with purple, 8 cm. long, 2 mm. thick, giving off adventitious roots from its base.

Cotyledons shortly petiolate, large, ovate, obtuse, entire, penninerved, convex above and green suffused with purple, concave beneath, with prominent midrib and primary nerves, 6 cm. long, 3·5 cm. wide; petiole channelled above, 4 mm. long, 3 mm. wide.

Stem erect, terete, and having two decurrent lines on each side, running down from the base of the petioles, purplish, sparsely pubescent with short white or crystalline hairs, flexuose at the nodes; 1st internode undeveloped; 2nd 7·2 cm. long, 1·5 mm. thick; 3rd 5 mm.; 4th 3·5 mm. or longer. Stem ultimately climbing by tendrils consisting of modified leaflets.

Leaves cauline, lower pair opposite, the rest alternate, exstipulate, petiolate, pinnately compound.

Nos. 1 and 2. Opposite, imparipinnate, consisting of three pairs of leaflets and a terminal one; leaflets half folded up face to face, oblong-lanceolate, acute, entire, subrevolute at the margins and convex above, unequal at the base, petiolate, with a prominent sunk midrib and primary lateral nerves, closely reticulate, sparsely pubescent on the upper surface; primary midrib channelled above, sparsely pubescent; petiolules subterete, tapering upwards from a stout base, pubescent, channelled above, 1·6 cm. long.

Nos. 3 and 4. Nearly opposite, sessile, pinnate and terminating in a tendril instead of a leaflet, otherwise similar to Nos. 1 and 2; tendril at first straight, alternately branched, slightly scabrous, purple, tapering towards the tip; branches slender, dichotomous, the ultimate branchlets hooked or clawed.

When the slender tip and branchlets have grappled or coiled round an object, an impulse is communicated to the lower unbranched part, causing it to coil up spirally and draw the plant to the supporting object.

HYDROPHYLLACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 825.

Fruit and Seed.—The ovary is superior and syncarpous, consisting of two carpels united by their edges only, forming a one-celled ovary with free or parietal placentas, or the latter are protruded into the centre, and touching one another form two spurious cells, or the septa cohere and form two distinct cells with prominent axile placentas. The ovules vary from two to many on each placenta and are anatropous or amphitropous. The fruit is capsular, dehiscing along the middle of each carpellary leaf with the valves bearing the placentas along their faces, or the placentas are erect and parallel with the valves. It more rarely happens that the fruit dehisces at the septa, or irregularly and separating from the axile placentas. The seeds vary in number from two to several, and are oblong, globose or angular. The testa is tubercular or rugose, smooth in one genus, Conanthus, with only one species. The endosperm is usually copious, fleshy and sometimes ruminated, surrounding a small embryo. The latter is straight with plano-convex or subterete cotyledons; the radicle is superior or points in various directions in different species.

The seeds of Nemophila parviflora are subglobose and variously angled with a rugose testa. The copious endosperm is ruminated. The embryo is small with orbicular cotyledons much shorter than the terete radicle. N. maculata has much larger, similarly angled seeds, ruminated endosperm, and a correspondingly large embryo of the same shape as that of N. parviflora. The seeds of Phacelia tanacetifolia are oblong, obtusely trigonous, and rather small. The embryo is rather elongated and slender, with linear cotyledons in the broader plane of the seed or obliquely to it. The terete radicle is rather elongated.

Seedlings.—The cotyledons of this Order are all of simple types, but they show a considerable amount of variation in different species even of the same genus. Orbicular, obovate, oval, ovate and linear types occur, with some slight modifications.

A number of species of Nemophila, including N. maculata (fig. 530), have orbicular or suborbicular cotyledons, the petioles of which are dilated and more or less connate. The first two leaves are pinnatisect with three segments, the terminal one of which is the largest and more or less deeply trifid. The following four or more leaves have five segments, the terminal one of which is the smallest. N. parviflora agrees somewhat with the above type, but the primary leaves are more distinctly in pairs, and the first two are less deeply divided. The seedling of N. phacelioides is chiefly notable for the much greater size of all its parts. The cotyledons are rather strongly penninerved, reticulate and hairy. The first two leaves are pinnatisect with oblong and cuneate, sometimes emarginate segments. The segments of the next two leaves are more or less deeply toothed or lobed; and all are hairy like the cotyledons.

A different type of seedling is met with in Nemophila insignis. The cotyledons are obovate-oblong, emarginate, trinerved and hairy. The first four leaves are pinnatifid with rounded segments. The cotyledons of Phacelia bipinnatifida are oval. The first leaf is triangular, subcordate at the base, and shallowly lobed. The next leaf is more decidedly characterised in this way, and has sometimes a separate segment or two cut away from the main portion of the lamina. The third leaf is more oblong and more deeply divided.

The whole seedling of Romanzoffia sitchensis closely resembles that of a Ranunculus. The base of the petioles of the cotyledons and leaves is dilated and sheathing. The lamina of the cotyledons is roundly-ovate or triangular, trinerved and glabrous. The first four leaves are palmately five-nerved and lobed with rather deep auricles. Wigandia Vigieri (fig. 532) is notable for the very small size of its ovate or rhomboid cotyledons. The first pair of leaves are ovate and entire, while the second pair are serrate. Succeeding leaves are much larger, oblong with a cordate base, and ultimately attain a great size.

The cotyledons of Phacelia tanacetifolia (fig. 531) are linear, petiolate and one-nerved. The first two pairs of leaves are opposite and twice divided with ovate-oblong primary segments. The secondary divisions are entire or toothed. The first three leaves of Phacelia Wrangeliana are small and ovate.

Nemophila maculata, *Benth.*

Ovary two- to twelve-ovuled; ovules pendulous, anatropous.

Fruit a one-seeded capsule.

Seed variously angled, generally almost subrotund, from 3–4 mm. in diameter; testa rugose, dark brownish; hilum inconspicuous; seed slightly flattened laterally.

Endosperm light brown, fleshy, copious, ruminated.

Embryo straight, embedded in the endosperm, colourless, cotyledons suborbicular or oblong, obtuse, entire, sessile, plano-convex, closely adpressed with their edges to the axis; radicle terete, obtuse, rather longer than the cotyledons, which lie in the broader way of the seed.

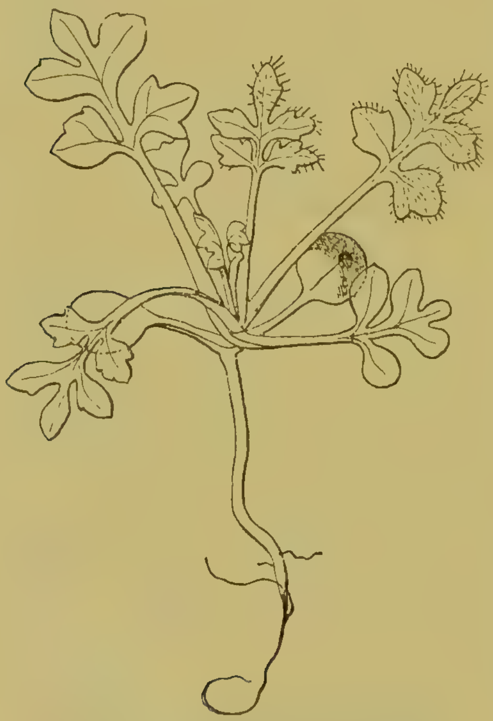

FIG. 530.—*Nemophila maculata.* Nat. size.

Seedling (fig. 530).

Primary root suddenly terminating in a slender point and furnished with a few lateral fibres, annual.

Hypocotyl tapering downwards, subflexuose, terete, sparsely pubescent, mostly subterranean and colourless, brownish at the top.

Cotyledons foliaceous, hairy; petiole channelled above, dilated and connate at the base, 1 cm. long; limb rotund, concave on the upper side, about 8 mm. in diameter.

Stem annual, internodes undeveloped in the young state.

Leaves simple, pinnatisect, radical (and ultimately cauline also), alternate, exstipulate, petiolate, coarsely hairy on all parts, deep green, sublucid.

No. 1. Pinnatisect; terminal segment largest, tridentate; lateral segments obovate.

No. 2. Pinnatisect; terminal segment transversely broader than long, trifid with rounded, obtuse, apiculate lobes; lateral segments obovate.

No. 3. Pinnatisect; basal lobes broadly subrhomboid, tridentate; middle pair of lobes irregular, subobovate, apiculate; terminal lobe small, obovate, apiculate.

Nos. 4 and 5. Similar to the last.

No. 6. Pinnatisect; basal pair of segments deeply dentate, ovate, with apiculate teeth; middle pair of segments tridentate with apiculate teeth; terminal segment obovate with a tooth on one side.

More segments are added to the leaf by segmentation of the terminal lobe as the plant gains in size and strength.

Nemophila insignis, *Benth.*

Hypocotyl erect, terete, glabrous, short, from 5–8 mm. long, almost colourless.

Cotyledons obovate-oblong, obtuse, slightly emarginate, rather unequal, petiolate, hairy on the upper side, glabrous on the lower, green, indistinctly trinerved; petioles flat, hairy.

Stem as in N. maculata.

First leaves pinnatifid, radical, opposite, oblong, obtuse, exstipulate, petiolate; lobes obovate or subrotund, entire or slightly lobed, pubescent, green, pinnatinerved; petiole flat, pubescent, very slightly channelled on the upper side.

Nemophila phacelioides, *Nutt.*

Hypocotyl short, terete, glabrous, hardly appearing above the soil.

Cotyledons large, subrotund, from 3–3·5 cm. in diameter, with a long petiole, obtuse, entire, sub-fleshy, covered with minute hairs on the upper side, glabrous beneath, light green, distinctly pinnatinerved.

Stem as in N. maculata.

First leaves simple, pinnatifid or pinnatisect, petiolate, exstipulate, radical, alternate, covered with bristly hairs above, glabrous beneath; lobes alternate, almost petiolate, obovate-oblong, entire or bi- to tri-lobed, light green, pinnatinerved.

Nemophila parviflora, *Benth.*

Ovary and *fruit* as in N. maculata.

Seed smaller than in N. maculata; testa yellowish-red, thin, becoming almost transparent near the apex.

Endosperm as in N. maculata, but almost colourless.

Embryo as in N. maculata.

Seedling.

Primary root tapering downwards and giving off strong lateral rootlets, annual.

Hypocotyl very short, erect, terete, slightly hairy or scaberulous, 4–6 mm. long, and tapering indistinguishably into the radicle.

Cotyledons more or less orbicular, petiolate, entire and tipped with a glandular mucro, or appearing sometimes slightly emarginate, rigid, subfleshy, usually concave owing to the centre growing faster than the margins, scabrido-pubescent on both sides, with an indistinct midrib but no other venation, deep green above, paler beneath or violet; lamina 6·5–9 mm. long, 5·5–8·5 mm. wide; petiole semiterete, flattened above, scabrido-pubescent, horizontal, dilated and connate at the base, 4–6 mm. long.

Stem diffuse, annual, with the primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, or lower opposite, exstipulate, petiolate, lobed, pinnatifid and pinnatisect, with alternate ascending nerves running into each of the principal segments and lobes, scabrido-pubescent all over, more or less concave or incurved at the margin or flat when young, deep green above, paler beneath; petioles semiterete, flattened above or shallowly grooved, dilated at the base and amplexicaul.

First pair pinnatifid, with one obovate, lateral lobe on each side, and a terminal broadly cuneate trifid one.

Second pair pinnatifid, with a pair of broadly cuneate, slightly dentate lateral lobes, and a broadly cuneate or transversely rhomboid, deeply trifid and slightly toothed terminal segment.

Third and fourth pairs pinnatisect at the base, and pinnatifid upwards, with the segments mostly trifid.

Phacelia tanacetifolia, *Benth.*

Ovary few-ovuled; ovules erect, anatropous; micropyle inferior.

Fruit a capsule, two-celled, two- to three-seeded.

Seed oblong, 1–1·5 mm. long, considerally flattened laterally; testa rugose, membranous; hilum inconspicuous.

Endosperm copious, fleshy, almost colourless.

Embryo straight, embedded in the endosperm, either at or very near the centre of the seed; cotyledons linear, obtuse, entire, almost flat, closely adpressed, lying either in the broader way of the seed, or obliquely to it; radicle long, terete, obtuse, narrow, shorter than the cotyledons.

Seedling (fig. 531).

Primary root long, tapering downwards, with a few lateral rootlets, annual.

Hypocotyl erect, terete, minutely and thinly pubescent, pale green or almost colourless, 1·8–2·5 cm. long.

Cotyledons linear, obtuse, petiolate, minutely pubescent, with a distinct midrib but no other venation visible in the fresh state; lamina 1·3–1·5 cm. long, 3–3·5 mm. wide, narrowed into the petiole; petiole semiterete, channelled above, pubescent on the edges above, or nearly glabrous, 7–9 mm. long.

Stem erect, terete, thinly glandular-pubescent with decurved hairs, pale green; 1st internode about 1·3 cm. long; 2nd about 2·3 cm.

Leaves simple, pinnatisect, cauline, opposite (at least in the lower part of the plant), exstipulate, petiolate, pubescent on both surfaces with bulbous-rooted short hairs directed towards the apex of the leaf and densely dotted with sessile glands; primary nerves opposite or alternate, ascending; secondary nerves alternate, ascending; petioles semiterete, shallowly channelled above, pubescent or more or less glandular-pubescent, tapering upwards from a broadish, semi-amplexicaul base.

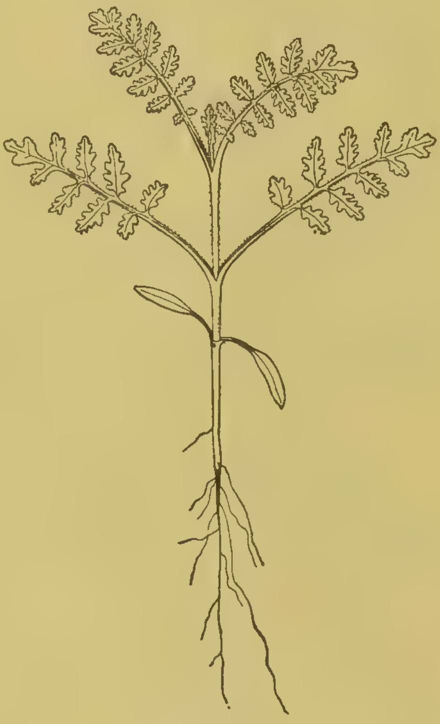

Fig. 531.—*Phacelia tanacetifolia.* Half nat. size.

Nos. 1 and 2. Opposite, oblong in outline, pinnatisect, pinnatifid; primary segments ovate-oblong, obtuse, shortly stalked; secondary segments short, rotund-oblong, obtuse, entire.

Nos. 3 and 4. Opposite, lanceolate or linear in outline, pinnatisect, pinnatifid; primary segments oblong, obtuse, narrowed towards the base and shortly stalked; secondary segments oblong, obtuse, slightly toothed.

Phacelia bipinnatifida, *Michx.*?

Primary root as in P. tanacetifolia.

Hypocotyl short, obconical, suddenly tapering into the root.

Cotyledons oval, submucronate, 1·1 cm. long, 8 mm. wide, sparsely hairy on the nerves, petiolate; petiole channelled above, dilated and connate at the base, 1 cm. long.

Stem ultimately developed when about to flower, annual.

Leaves radical (and ultimately cauline), alternate, exstipulate, petiolate, coarsely hairy especially when young and on the petioles; petioles channelled above, dilated and subamplexicaul at the base.

No. 1. Triangular-subcordate, coarsely dentate or lobulate, rather indistinctly nerved above, more prominently beneath.

No. 2. More elongated and pinnatifid or pinnatisect; terminal segment very large, five-lobed; lateral segments one or two, very small, oval or elliptic.

No. 3. Pinnatisect with one to two small lateral segments, and a large terminal sub-bipinnatifid one.

Ultimate leaves lyrate-pinnatisect, pinnatifid; lateral segments alternate, very irregular in size and division, ovate or oblong, acutely incise-serrate or pinnatifid, frequently exhibiting small intermediate segments cut away from the posterior basal side; terminal segment much the largest, triangular, trinerved, lobed or pinnatifid, and coarsely incise-serrate, often with small oval, or elliptic, acute, entire segments cut away from its base.

Romanzoffia sitchensis, *Cham.*?

Primary root tapering downwards and giving off a few lateral rootlets, soon superseded by numerous, strong adventitious roots from the base of the cotyledons and leaves.

Hypocotyl undeveloped.

Cotyledons rotund-ovate, obtuse, entire, petiolate, trinerved, with the lateral nerves incurved and uniting with the midrib below the apex, minutely glandular-pubescent on both surfaces, deep opaque green above, paler beneath, tipped with a gland; lamina 3–4·25 mm. long, 2·5–4·25 mm. wide; petiole flattened above, convex on the back, tapering upwards from a broad, dilated and slightly connate base, minutely glandular-pubescent, reddish-purple, 2·5–6 mm. long.

Stem herbaceous, and developed only when about to flower, about six inches long; primary internodes undeveloped.

Leaves radical and cauline, alternate, exstipulate, petiolate, palmately nerved and toothed or lobulate, slightly hairy on both surfaces with pale-coloured jointed hairs, deep opaque green above, paler beneath; petioles semiterete, slightly flattened above, much dilated and clasping at the base, hairy or almost villous with pale jointed hairs, especially in the hollow dilated bases.

No. 1. Cordate, palmately three- to five-nerved, and toothed with glandular-mucronate, obtuse teeth.

Nos. 2 and 3. Reniform, five- or six-nerved with glandular-mucronate, obtuse teeth.

No. 4. Reniform, palmately seven-nerved and toothed or sublobulate.

Wigandia Vigieri, *Hort.* (fig. 532).

Primary root tender, succulent, flexuose, frequently giving off rootlets at the angles.

Hypocotyl short, tapering downwards, colourless under the soil, red above it and hairy, 3–5 mm. long.

Cotyledons very small, petiolate, pubescent, pale green; lamina rhomboid, acute, 2 mm. long, 1·5 mm. wide; petiole 1–1·25 mm. long.

Stem erect, terete, densely and coarsely hairy, succulent in the young stage, purple; internodes very variable, bringing the early leaves nearly or quite opposite.

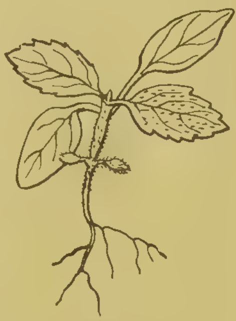

FIG. 532.
Wigandia Vigieri.
Nat. size.

Leaves simple, cauline, alternate (or a few of the seedling leaves opposite), exstipulate, petiolate, coarsely hairy on both sides, deep green above with a purple midrib and frequently splashed with purple, paler beneath and irregularly splashed with purple, alternately penninerved; petioles subterete, narrowly channelled above, tapering upwards from a stout base.

Nos. 1 and 2. Small, opposite, ovate, obtuse, entire.

Nos. 3 and 4. Opposite, ovate, subacute or obtuse, serrate.

No. 5. Alternate, oblong, acute, cordate at the base, irregularly or somewhat doubly dentate.

No. 6. Cordate-oblong, obtuse, doubly dentate.

No. 7 and 8. Cordate, elongate, acute, doubly dentate.

BORAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 832.

Fruit and Seed.—The ovary is superior, syncarpous, and consists of two carpels each of which is two-ovuled. Sometimes it is entire, or again more or less deeply four-lobed and two-celled, or the cells may be divided by spurious septa or strongly involute placentas, thus making the ovary more or less distinctly four-celled, each cell with a single ovule. In other cases the ovary is four-lobed and four-celled, with the central part entire and together with the gynobasic style persistent. It more rarely happens that the lobes are connate in pairs, and each two-celled, or that there are two lobes, each containing one ovule. The ovules are erect, oblique or horizontal, and inserted at the base or towards the apex of axile placentas. The micropyle is superior or faces the axis. The fruit is drupaceous, and two- to four-celled with a woody endocarp, or breaks up into two to four pyrenes, or fewer by abortion. In these cases the exocarp is fleshy, baccate or thin. There are many familiar instances where the fruit breaks up into four nutlets, or fewer by abortion, with a hard or sometimes fleshy exocarp or shell, one-seeded and indehiscent. The seed like the ovule is erect or oblique, rarely horizontal, straight or incurved, and conforming to the interior of the cells, pyrene, or nutlet as the case may be. The testa is membranous. Endosperm is copious and fleshy, or scanty, and at other times entirely wanting. The embryo is straight or curved in conformity with the seed, while the cotyledons vary greatly, being flat, plano-convex, thick and fleshy, and entire. A few cases occur where the cotyledons are bifid, and others where they are much plaited. The radicle is generally short and superior, or facing the axis.

The cotyledons are plaited in the tribe Cordieæ, bipartite in the genus Amsinckia, and the radicle is subinferior in some members of the subtribe Cynoglosseæ.

The plaited character of the cotyledons is well shown by Cordia subcordata (fig. 534). The folds are longitudinal and deep, causing the cotyledons to be toothed or notched at the apex. The fruit is undivided, nut-like and four-celled, but three out of the four cells are usually empty or contain aborted ovules only. The endocarp is woody or bony, elevated on its outer surface into longitudinal and transverse ridges, and covered by a fleshy exocarp, becoming cortical when dry. The plaiting of the cotyledons in the nut of C. subopposita is less deep and perhaps more irregular. A section shows two small and two large but empty cells, while a fifth contains a perfect embryo. This number of cells is however probably quite abnormal. An imperfect fruit of C. grandifolia (fig. 533) shows three small cells towards one side of the endocarp, while there is a larger but empty one in the centre.

The most familiar examples of the Boragineæ have fruit which breaks up into four one-seeded nutlets to the interior of which the seeds and embryo conform. Endosperm is usually wanting and the cotyledons are plano-convex and rather fleshy. Borago officinalis is an example of this type. The embryo is straight and ovoid, with oval plano-convex cotyledons. The nutlets of Cynoglossum vulgare are larger, covered with coarse, hooked bristles, obovoid and somewhat compressed. The cotyledons are broadly obovate. The epicarp of Symphytum asperrimum is unequally thickened, one side having a thick wall, but it is quite smooth. The cotyledons are oval or oblong, rounded at the end and plano-convex. The nutlets of Myosotis arvensis are ovoid, smooth, and very small. The cotyledons are broadly obovate or oval and otherwise quite typical. The nutlets of Lithospermum officinale are also ovoid and polished as in Myosotis, but they are much larger. The walls are very thick and bony, and the seed with the embryo conforms closely to the interior. The cotyledons are broadly oval or obovate and entire. The nutlets of Echium vulgare are ovoid, subconical, slightly incurved upwards, keeled on the dorsal aspect and covered all over with little warts or protuberances. The hilum of the seed is above the middle of the ventral aspect. The seed and embryo are slightly incurved in conformity with the nutlet. The cotyledons are broadly oblong or oval. In all of the above cases belonging to this type the radicle is superior and very short.

A third type is met with in Amsinckia, the cotyledons of which are bipartite. The nutlets of A. longifolia are ovoid, elongated, somewhat trigonous and rugose or warted on the surface. The cotyledons have oblong lobes so arranged as to occupy the angles of the seed and fruit. The angular character of the nutlet may explain the necessity for fission of the cotyledons which would otherwise fit awkwardly into the angles.

Seedlings.—There are at least five or six different types of cotyledons amongst the Boragineæ. One of the most remarkable is that represented by Cordia latifolia which has broad subrhomboid-cuneate, somewhat plaited, five-nerved cotyledons. The three primary nerves are much branched with the branches terminating in the notches between the crenatures of the apical margin of the lamina. The crenatures are due to the way in which the large cotyledons are longitudinally folded or plaited in the seed. Other instances are met with in which the midrib ends in an apical sinus, such as Brassica and Convolvulus as well as all or most cases where the cotyledons are bifid or emarginate, but the case of numerous crenatures with the stronger secondary as well as the primary veins ending in the notches is probably unique as far as the genus Cordia is concerned. The hypocotyl of C. latifolia is very short. The first leaf is small, oblong and entire, while the two following leaves are much larger and thinly serrated above the middle. The seedling of C. subcordata (fig. 535) is altogether taller and more robust with a long hypocotyl. The cotyledons are transversely oval, longitudinally plicate, and otherwise like those of C. latifolia. The first leaf is ovate, acuminate, and the second cordate, The cotyledons of C. decandra are obovate-elliptic, plicate, crenate at the apical margin, pubescent and penninerved. An exceptional case occurs in C. ferruginea which has broadly obovate-cuneate, trinerved, entire cotyledons. The first two leaves are oblong-lanceolate and subopposite.

A third type occurs in Lithospermum officinale (fig. 538) which has obovate or roundly-elliptic, emarginate cotyledons; hairy on the upper surface. The first two leaves are opposite but unequal in size, oblong-elliptic and entire. The cotyledons of Echium canescens are suborbicular or oblate and hairy, with a wide shallow apical sinus.

The cotyledons of some species vary between obovate, oblong-obovate and spathulate. Those of Anchusa capensis are broadly obovate, entire, penninerved and hairy. The first leaf is lanceolate-oblong, tapering to the base, penninerved and hairy. Those of Echium violaceum differ chiefly in having a more oval lamina. The first pair of leaves are oblong-oval and opposite. The seedling of Eritrichium barbigerum is altogether smaller, with spathulate hairy cotyledons showing only a somewhat obscure midrib.

Suborbicular cotyledons occur in a number of species including Tournefortia ferruginea (fig. 536). They are subtruncate at the base, trinerved, finely pubescent with rather slender petioles. Those of Omphalodes linifolia are smaller, glabrous, glaucous and one-nerved. In the case of Echium Decaisnei they are small, rotund, and concave. The leaves are all lanceolate or oblong-lanceolate, finely and densely hairy on both surfaces, and appear to vary only in size from the seedling onward to the adult state.

A most remarkable type is met with amongst the species of Amsinckia in which the cotyledons are bifid or bipartite. In A. intermedia (fig. 537) they are cut down to the petioles, with spathulate, hairy, one-nerved, entire, somewhat stalked and divaricate lobes. Two or more of the primary leaves are linear and hairy.

Cordia subopposita, *DC.*

Fruit a nut, or drupe according to some authors, oblong-ellipsoid, tipped with the remains of the terminal style, glabrous, dark-coloured, four- rarely three- or five-celled, or by abortion reduced to one or more fertile or seed-bearing cells, while the others are empty; exocarp in the dried state forming a layer of dry, softish, cellular material; endocarp bony, ellipsoid, subtetragonal, tapering above and below the middle, with four slightly excavated or sculptured sides above the middle, slightly notched at the base and shortly bifid at the apex, pale brown or straw-coloured.

Seed obovoid, somewhat compressed laterally, and subconical at the tip; testa thin, membranous, smooth, white, micropyle at the upper and pointed end of the seed; hilum lateral and attached to the inner angle of the cell.

Endosperm absent.

Embryo straight, large, filling the entire cavity of the seed, colourless; cotyledons very broad, rounded, crenate, much plaited from the testa towards the centre of the seed so as to occupy the whole of the space, thick and subfleshy; radicle short, stout, turbinate, obtuse, lying in the conical tip of the seed, and pointing to the base of the style.

Cordia grandifolia, *DC.* (fig. 533).

Fruit a drupe, or rather a nut when mature and dry, four-celled, but usually only one cell contains a perfect embryo, which is transverse to the axis and oblong-subreniform, closely covered with fine adpressed hairs, lying in the broad, almost flattened, five-lobed calyx; pericarp crustaceous when dry or subcoriaceous; endocarp bony, except at the receptacle where a cavity is left filled with rather soft, cortical, pale-coloured tissue, nearly smooth except on the upper side which is raised into numerous tooth-like elevations, smooth and differently coloured on the ventral aspect near the top, denoting the presence of the three aborted lobes of the ovary. A transverse section of this part showed one large and three small cavities, the latter of which were empty.

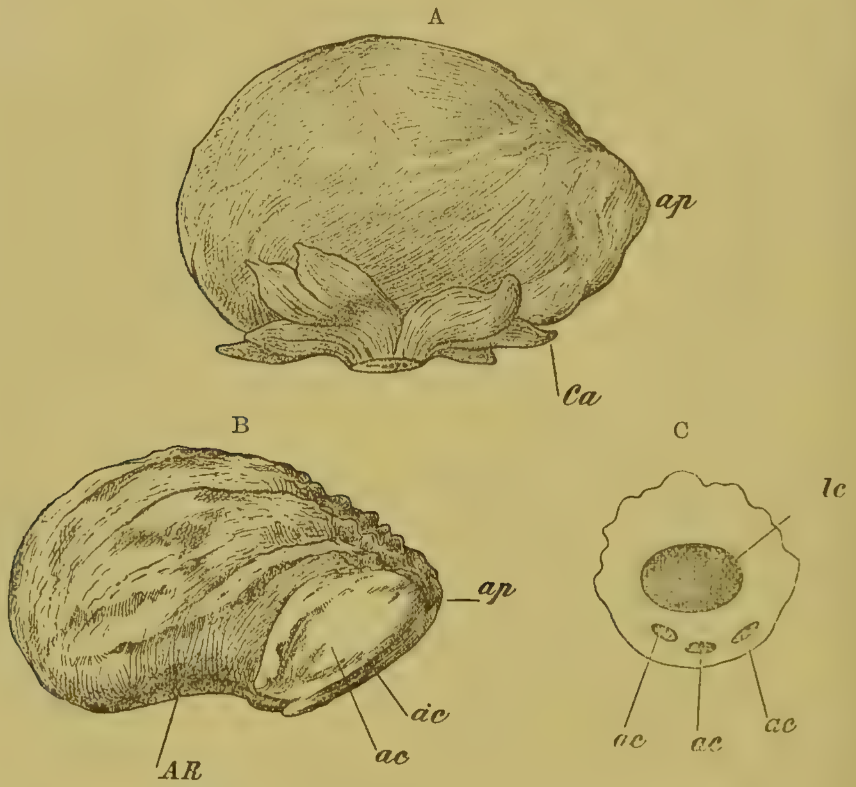

Fig. 533.—*Cordia grandifolia.* A, fruit, × 4: *Ca*, calyx; *ap*, apex of fruit. B, endocarp and seed, or nut, × 4: *AR*, attachment to receptacle; *ap*, apex of nut; *ac*, *ac*, aborted cells of ovary. C, transverse section of nut, × 4: *ac*, *ac*, *ac*, aborted cells of ovary; *lc*, large cell usually containing a seed, but here empty.

Cordia subcordata, *Lam.* (fig. 534).

Fruit a nut (by some called a drupe) enclosed in the enlarged calyx-tube, four-celled, four-seeded, or by abortion fewer, indehiscent, and not separating into nutlets as in the more typical Boragineæ; epicarp forming a thick cortical pale brown stratum; the bony endocarp with longitudinal and a few more or less acute transverse ridges, embedded in the cortical layer. In the fruit examined one cell had a perfect embryo or seed, while all the other ovules were aborted and the cells very small.

Seed conforming to the interior of the cell which it fills, ovoid-conical, glabrous, pale-coloured; testa very thin, soft, separable into an outer cortical layer, and an inner white layer; micropyle superior at the pointed end of the seed, and indicated by a small dark-coloured spot.

Endosperm absent.

Embryo large, straight, occupying the whole interior of the seed; cotyledons large, much plicate longitudinally and crenate at the margin, folded from the circumference towards the centre of the seed, and from thence back again, and this is continued all round the interior of the seed, rather thick, fleshy, and colourless; radicle very short, stout, turbinate, obtuse, lying externally to the cotyledons and occupying the conical tip of the seed, close to the micropyle which is dark-coloured.

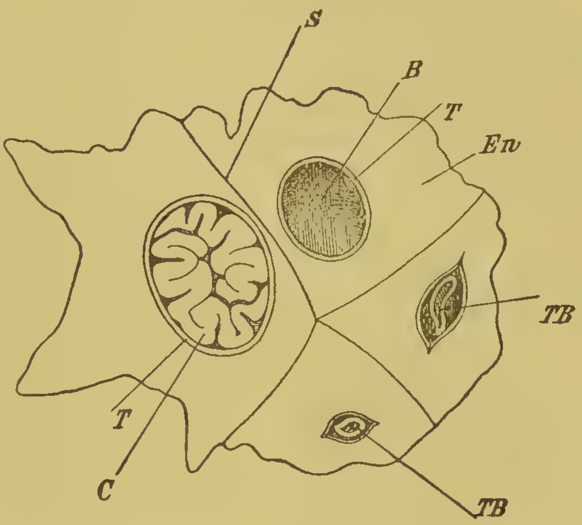

FIG. 534.—*Cordia subcordata.* Transverse section of nut, × 4: *T*, testa; *C*, cotyledon; *TB*, *TB*, testa of barren seeds in empty cells; *En*, endocarp; *B*, barren cell with testa, *T*; *S*, sutural line.

Seedling (fig. 535).

Hypocotyl suffruticose, densely covered with short stiff hairs, 7 cm. long.

Cotyledons petiolate, soft and succulent, becoming coriaceous, transversely oval, roundish or oblong, crenate, plicate, subcordate at the base, palmately three- to five-nerved with numerous strong lateral veins ascending from the primary ones, pale green above and covered with a dense adpressed pubescence, paler beneath and glabrous except on the nerves; petiole somewhat flattened above, convex beneath, densely pubescent, 8·5 mm. long.

Stem erect, terete, becoming woody, densely covered with an adpressed or ascending pubescence, pale green; 1st internode 2·3 cm. long, 1·5 mm. thick; 2nd (when sketched) 5 mm. long.

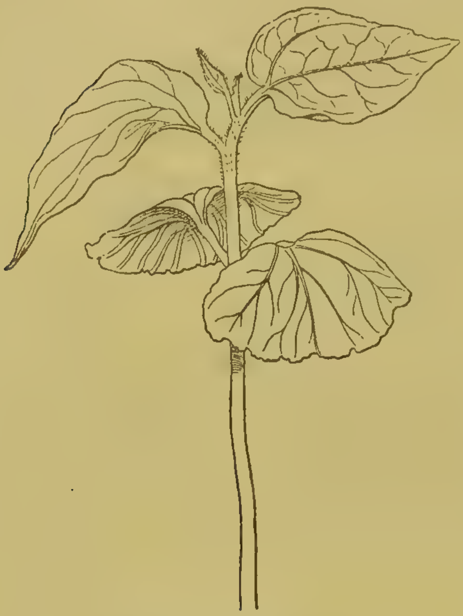

Fig. 535.—*Cordia subcordata.* Half nat. size.

Leaves simple, cauline, alternate, exstipulate, petiolate, sparsely pubescent on both surfaces with short, adpressed, white, rather stiff hairs, quite entire.

No. 1. Ovate, acuminate, very unequal at the base, subconcave, involute and wavy at the margin, penninerved and reticulate, acute; petiole flattened above, convex beneath, covered with a dense adpressed pubescence pointing towards the apex, 6 mm. long.

No. 2. Cordate, acute, slightly unequal at the base, subtrinerved and reticulate; petiole 5 mm. long.

Cordia latifolia, *Roxb.*

Hypocotyl erect, terete, stout, fleshy, glabrous, green.

Cotyledons very large, and similar to those of C. subcordata.

Stem erect, terete, hairy, pale green, ultimately woody; 1st internode 5 mm. long; 2nd 1·25 mm.; 3rd 1 mm.

Leaves alternately and ascendingly penninerved (with the nerves ending in marginal serratures), reticulate, minutely ciliate, and hairy on the midrib, otherwise glabrous, membranous, light green; petiole stout, short, semiterete, channelled above, hairy.

No. 1. Oblong, obtuse.

No. 2. Cuneate, obovate, mucronate, cuspidate, irregularly serrate above the middle, with obtuse mucronate serratures.

No. 3. Oblong-obovate, otherwise like the last.

Cordia decandra, *Hook. et Arn.*

Hypocotyl long, stout, 2·5–3 cm. long, pubescent, terete, light green or almost colourless.

Cotyledons obovate-elliptic, obtuse, crenate, wrinkled, wide, subsessile, pubescent, green, very distinctly pinnatinerved.

Cordia ferruginea, *Roem. et Schult.*

Hypocotyl erect, terete, minutely pubescent, 1–2·5 cm. long, light green or almost colourless.

Cotyledons broadly obovate, obtuse, entire, cuneate at the base, petiolate, glabrous, green, brighter beneath, trinerved.

Stem erect, terete, herbaceous, minutely pubescent; 1st internode 1·25–2 mm. long.

Leaves.—First pair simple, entire, cauline, subopposite, lanceolate, acute, with short petioles, exstipulate, hairy, green, pinnatinerved.

Tournefortia ferruginea, *Lam.* (fig. 536).

Hypocotyl erect, terete, pubescent, stoutish, 1·5–2·2 mm. long, light green or almost colourless.

Cotyledons broadly subrotund, somewhat truncate at the base, obtuse, entire, petiolate, minutely pubescent, green, trinerved; petioles rather flat. The cotyledons in some cases appear to have considerable difficulty in freeing themselves from the woody testa.

Stem erect, terete, herbaceous, pubescent, ultimately woody; 1st internode 6–10 mm. long; 2nd 5–6 mm.

First leaves simple, entire, cauline, opposite, decussate, exstipulate, petiolate, ovately oval, obtuse, ciliate, densely pubescent, green, somewhat wrinkled, pinnatinerved; petioles long, pubescent, channelled above.

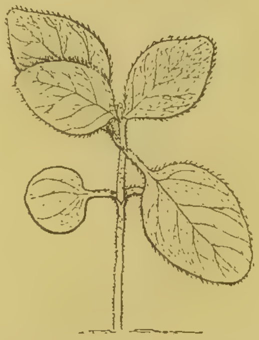

Fig. 536.—*Tournefortia ferruginea.* Half nat. size.

Omphalodes linifolia, *Moench.*

Hypocotyl erect, terete, glabrous, light green or colourless, 6–8 mm. long.

Cotyledons rotund, obtuse, entire, petiolate, glabrous, pale subglaucous-green, one-nerved; petioles broad, rather flat and shallowly channelled on the upper face.

Stem with primary internodes undeveloped, annual.

First leaves simple, entire, cauline, opposite, afterwards alternate, broadly spathulate or obovate, obtuse, petiolate, exstipulate, glabrous, pale glaucous-green, very indistinctly pinnatinerved; petioles broad, flat, shallowly channelled on the upper face.

Cynoglossum vulgare, *Güldenst.*

Ovary of two carpels, each two-ovuled; ovules anatropous, pendulous or almost horizontal; micropyle superior.

Fruit consisting of four nutlets, the pericarps of which are covered with coarse hooked bristles.

Seed conforming in shape to the fruit, obovate, obtuse, exalbuminous, considerably flattened; testa smooth, membranous; hilum conspicuous.

Embryo straight, filling the seed, colourless; cotyledons broadly obovate, obtuse, entire, plano-convex, lying face to face the broad way of the seed with their faces to the axis; radicle short, obtuse, terete, much shorter than the cotyledons.

In **C. furcatum**, *Wall.*, the seed is similar in all respects to that of C. vulgare, but much smaller, more flattened, and the pericarp is covered with proportionally longer bristles.

Eritrichium barbigerum, *A. Gray.*

Hypocotyl short, erect, terete, 1–1·5 mm. long, green or almost colourless.

Cotyledons subfleshy, spathulate, obtuse, entire, tapering to the base, covered with rather stiff hairs on the upper side, glabrous beneath, green, indistinctly one-nerved.

Stem erect, terete, hairy, herbaceous; 1st internode ·75–1·25 mm. long; 2nd shorter.

First leaves simple, entire, cauline, opposite, decussate, sessile, tapering to the base, exstipulate, spathulate-linear, obtuse, covered with rather stiff hairs or bristles, green, distinctly one-nerved.

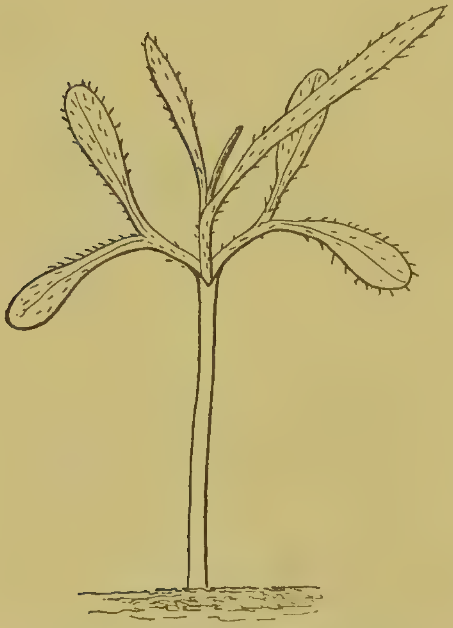

FIG. 537.—*Amsinckia intermedia*, × 2.

Amsinckia intermedia, *Fisch. et Mey.* (fig. 537).

Hypocotyl erect, terete, glabrous, 1·6–2 cm. long, light green.

Cotyledons deeply bipartite, divided nearly to the base, with spathulate, obtuse, somewhat stalked, one-nerved, hairy, divaricate divisions. When the seedling first appears above ground the segments are linear, erect, but soon diverge, widen and lengthen till they become spathulate.

Leaves simple, cauline, alternate, exstipulate, hairy.

Nos. 1 and 2. Linear, suba ute, entire.

Borago officinalis, *L.*

Pistil syncarpous, superior; ovary of two carpels, deeply divided into four parts, which ultimately fall away from the receptacle as four nutlets; nutlets erect, oblong, terminated by an acute shallow ridge that runs along the apex and down the inner angle, constricted a little above the base giving the latter a tumid appearance, striated longitudinally with shallow, more or less toothed or muricated ridges on all sides, pale green when immature, ultimately brown; style gynobasic; ovules solitary in each of the four parts of the ovary, pendulous, anatropous; micropyle close to or at the apex.

Fruit breaking up into four indehiscent nutlets, which before maturity are seated on a tumid or fleshy body, rounded on all sides except where the seed comes in contact with it.

Seed ovoid-oblong, smooth, with a broad base and suddenly tapered to a small point at the apex, pale green when immature, conforming to the smooth inner surface of the pericarp from which it never escapes; radicle superior or at the apex of the seed, forming a small turbinate point.

Endosperm absent.

Embryo always straight, oval or elliptic in outline, fleshy, milk-white, suspended from the narrow apex of the seed; cotyledons plano-convex, applied face to face, oval or elliptic in outline, perfectly straight and entire, rather rounded at the apex and tapering to the small turbinate radicle.

Anchusa capensis, *Thunbg.*

Hypocotyl erect, terete, 4–5 mm. long, light green or colourless, glabrous.

Cotyledons broadly obovate-oblong, obtuse, entire, shortly petiolate, hispid above, glabrous beneath, green, indistinctly pinnatinerved like the leaves.

Stem with the primary internodes undeveloped.

First leaves simple, entire, radical, alternate, oblong, obtuse, tapering at the base to a broad petiole, exstipulate, hispid, green, pinnatinerved.

Myosotis arvensis, *Hoffm.*

Fruit of four nutlets, each one-seeded and oval, with their pericarps smooth and greenish.

Seed conforming in shape to the nutlets from ·75–1 mm. long, slightly laterally flattened; hilum inconspicuous.

Endosperm wanting.

Embryo straight, filling the seed, colourless; cotyledons broadly obovate, obtuse, entire, lying in the broad way of the seed with their edges to the axis; radicle short, terete, obtuse, much shorter than the cotyledons.

Lithospermum officinale, *L.*

Fruit of four nutlets, or fewer by abortion, each one-seeded, ovoid; walls of nutlet thick, woody, externally bluish-white, of stony hardness and appearing enamelled.

Seed ovoid, conforming to the interior of the nutlet, to which it is closely applied, occupying the whole of the interior except a small empty space at the ventral suture, laterally attached to the placenta, and by growth subsequent to fertilisation appearing basally attached or nearly so; radicle superior.

Endosperm absent.

Embryo straight, large, obovoid, pale yellowish-white, occupying the whole interior of the seed; cotyledons oval, rounded and entire at the apex, plano-convex and thick; radicle turbinate, obtuse, much shorter than the cotyledons and directed into the obtusely conical point of the nutlet and seed.

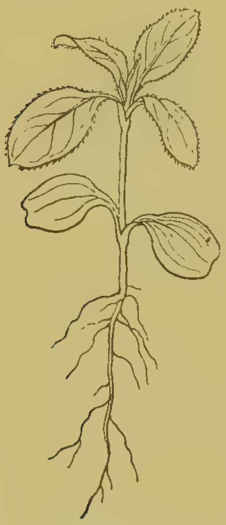

Fig. 538. *Lithospermum officinale.* Half. nat. size.

Seedling (fig. 538).

Primary root normal, tapering, fibrous.

Hypocotyl erect, terete, pale green, pubescent, 3–9 mm. long.

Cotyledons obovate or subrotund-elliptic, emarginate, tapering into the petiole, light green, with short, bulbous-rooted hairs on the margin and upper surface, nearly glabrous beneath, with a distinct midrib but no lateral nerves; lamina 1·5 cm. long, 1–1·3 cm. wide; petiole broad, shallowly grooved above, perfoliate at the base, closely pubescent, pale green, 6–8 mm. long.

Stem herbaceous, erect, terete, closely covered with adpressed pubescence, directed upwards, pale green; 1st internode 1·8–2·7 cm. long; 2nd undeveloped; 3rd slightly elongated.

Leaves simple, entire, cauline, alternate (first two opposite), exstipulate, petiolate, covered all over with subadpressed, bulbous-rooted hairs, pale green; petioles rather broad, flattened, shallowly grooved above, hairy like the leaf, semiamplexicaul at the base.

Nos. 1 and 2. Oblong-elliptic, minutely cuspidate, opposite, but unequal in size, with a few alternate, ascending nerves.

Nos. 3 and 4. Slightly alternating with each other, lanceolate-elliptic or narrowly elliptic, minutely cuspidate, with a few alternate, ascending nerves.

Ultimate leaves narrowly lanceolate.

By bleaching the cotyledons it may be seen that two pairs of nerves arise in the petiole, the lower of which is short, but the next pair follows the curve of the cotyledon at some distance from the margin, and unites with a third pair arising below the middle of the cotyledon, and describing a curve joins the midrib close to the apical sinus. Smaller branches anastomose copiously with all these.

Stomata are numerous on the under side, fewer on the upper. The epidermal cells are very wavy on the under side, but less so above.

The margin of the cotyledon and the base of the sinus especially have large open pores. The thickened apex of the midrib shows a few discoloured openings on the upper surface, but more numerous and conspicuous below. They are rounder than the stomata, and some of them at least are surrounded with four guard cells. The emargination of the cotyledons takes place after germination, and is due to the tissues on each side of the sinus growing more rapidly than the portion bearing the water-gland and the water stomata.

Echium vulgare, *L.*

Fruit breaking up into four (or fewer by abortion), one-celled, one-seeded nutlets which are ovoid-subconical, slightly incurved upwards, somewhat constricted above the horizontal attachment at the base, and again above the part occupied by the cotyledons, scabrid all over the surface or raised into little prominences, carinate along the upper part of the dorsal aspect, and along the whole length of the ventral suture, brown.

Seed ovoid, subcompressed dorsally, and slightly curved, owing to the curvature of the nutlet which it closely occupies ; testa thin, membranous, yellowish ; hilum above the middle on the ventral aspect ; raphe and chalaza consisting of nerves, radiating from the hilum to the broad lower part of the seed ; micropyle and radicle superior in the tip of the nutlet and some little distance above the hilum.

Endosperm absent.

Embryo slightly incurved owing to the shape of the seed and nutlet, large, and occupying the whole of the seed, yellowish ; cotyledons broadly oblong, short, obtuse, entire, plano-convex, closely adpressed face to face ; radicle occupying the conical tip of the seed and conforming to it in shape, less than half the length of the cotyledons.

Echium canescens, *Presl.*

Hypocotyl erect, terete, hairy, 2·5–3 cm. long, light green or colourless.

Cotyledons broadly rotund or oblate, obtuse, shallowly emarginate, petiolate, pubescent, green, indistinctly trinerved or almost pinnatinerved ; petiole broad, flat, shallowly channelled above.

Stem with the primary internodes undeveloped.

Echium violaceum, *L.*

Hypocotyl as in E. canescens, 1–1·2 cm. long.

Cotyledons broadly oval, entire, obtuse, with broad flat petioles, hairy, green, pinnatinerved as in the leaves.

Stem as in E. canescens.

First leaves simple, entire, radical, opposite, oblong-oval, obtuse, petiolate, exstipulate, hispid, green, pinnatinerved ; succeeding ones alternate.

Echium Decaisnei, *Webb et Berth.*

Hypocotyl wiry, about 1·5 cm. long.

Cotyledons rotund, concave, shortly petiolate, about 8 mm. long, 4·5 mm. wide.

Stem erect or subflexuose, terete, and thickening upwards, woody, hispid with white, broad-based hairs ; internodes numerous, short, 4–8 mm. long.

Leaves cauline, alternate, simple, entire, exstipulate, petiolate, numerous ; limb lanceolate, obtuse or acute, penninerved, tapering to both ends, softly and densely hairy above with sunken nerves, pale green on both surfaces, densely hairy beneath with prominent midrib and lateral ascending nerves ; petiole channelled above, convex beneath, dilated at the base and half amplexicaul, hispid, varying in length according to the size of the leaf which gradually increases successively from the base of the stem upwards.

CONVOLVULACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 865.

Fruit and Seed.—The ovary is superior and syncarpous, consisting usually of two carpels, rarely of three, five, or ten, and cohering so as to form as many cells as there are carpels. In some cases there are spurious septa interposed dividing the ovary into as many cells as there are ovules. The ovary is generally entire, but in rarer cases is divided into distinct erect lobes. The ovules are usually geminate in each cell, rarely one or four, sessile, basal, erect from the inner angle of each cell, anatropous or nearly so. The fruit is generally entire and globose, rarely oblong or conical, fleshy, baccate, pulpy and indehiscent, or capsular as in the typical genus, with hardened, crustaceous or membranous walls, indehiscent or dehiscing by two to four valves, rarely bursting irregularly or transversely operculate. In other cases the fruit is divided into two to many lobes, each piece constituting an indehiscent one-seeded nutlet; or it may be divided into as many cells as there are seeds when the latter are numerous. The seeds are as numerous as the ovules or fewer by abortion, basal from the inner angles of the cells and erect. When solitary they conform to the cavity of the fruit, but when there are two or more they become angled by mutual compressure. The testa is membranous or crustaceous, rarely fleshy and smooth, villous or woolly. Endosperm is present and fleshy or more usually forms a thin layer occupying the space between the various parts of the embryo. The latter is large and variously folded with thin and foliaceous cotyledons which are entire, emarginate, bifid or bipartite. More rarely the embryo is terete, curved and subspherical, or spiral with elongated semiterete or obsolete cotyledons. The radicle is inferior, directed towards the hilum and often more or less curved round the dorsal aspect of the seed. An exceptional case occurs in Nephrophyllum where the embryo is terete and much curved, with spiral cotyledons scarcely wider than the radicle. In the same category Nolana, Alona, and Dolia may be placed. The species of Cuscuta have an embryo consisting of a terete spiral body with inconspicuous or obsolete cotyledons. A well-marked type of seed occurs in the numerous species of Convolvulus and Ipomœa, and as they correspond pretty closely they may be taken together. When more than two seeds reach maturity in a capsule, they are bluntly trigonous with the hilum basal, and facing the inner angle of the cell obliquely. The interior of the seeds is remarkable for an invagination of the tegmen along the ventral angle. The extent to which it is infolded varies greatly in different species; in all cases it is perhaps most marked at the apical end of the seed, and from thence it is continued towards the base. The seeds of some species are almost two-celled owing to the excessive development of this peculiar process, and a small opening is left just sufficient to permit of the embryo pushing half of each cotyledon into each of the halves of the seed. There is also a singular invagination of the micropyle close to the hilum, forming with the dorsal integument of the seed a tubular cavity in which the embryo arises, and which ultimately accommodates the radicle only. This is not so rare an occurrence as the first mentioned process, as we meet with it in species belonging to various Orders, although generally it is much less marked. Something like it occurs in Acer and Æsculus belonging to the Sapindaceæ. The embryo is large, and during development the cotyledons grow till they reach the apex of the seed or till they meet the invagination of the tegmen when the growth of the primary axis or midrib is stopped; or if it continues to grow, then the cotyledons become folded transversely upon themselves in the dorsal region of the seed. Sooner or later however the cotyledons become concave on the ventral aspect, and obliquely lateral lobes are developed so as to occupy the cells on each side of the invaginated tegmen. This causes the cotyledons to become emarginate, bifid or bipartite according to the length of the lateral lobes. When the latter attain great length they become very much folded, plicate or crumpled, giving the cotyledons the characteristics which mark them after germination. When the seeds are large and the cotyledons but little folded, the latter are but shallowly bifid or merely emarginate after germination; but when the seeds are small and the cotyledons are much folded, they appear deeply bifid and bipartite after germination. The species of Convolvulus and Ipomœa observed may for convenience sake be divided into those which have merely emarginate, and those which have bifid, deeply bifid, and bipartite cotyledons. Convolvulus Soldanella may be given as a type having the cotyledons merely emarginate. The amount of the invagination of the tegmen is small; the cotyledons undergo little folding in the seed, and they are seen to be five-nerved at the base even at a very early stage. The midrib forks a little way before reaching the sinus of the cotyledon, and this is what occurs in many, if not in all of the species coming under my notice. There is a more or less direct relation between the length of the midrib and the depth of the lobing, for the longer the lobes are the shorter the midrib which represents the real length of the axis of the cotyledon.

Convolvulus sepium agrees pretty closely with this type, as does also C. tricolor.

The cotyledons of Ipomœa purpurea are shallowly bifid, and the amount of folding is moderate in the seed; but the infolding of the tegmen is considerable.

The seed of Ipomœa Pes-capræ is almost two-celled owing to the ingrowth of the tegmen on the ventral aspect, and the invagination of the micropyle is also considerable. The cotyledons are deeply bifid, but the amount of folding of the lateral lobes is moderate, and the length of the midrib is considerable owing to transverse folding on the dorsal aspect of the seed just after leaving the tube from the micropyle and before the lamina divides. This particular folding is due to growth in length of the lamina after the apical sinus comes in contact with the obstruction caused by the tegmen. The advantage or economy of the latter may be to prevent the lobes of the cotyledons from getting intricately confused with one another, thereby rendering exit from the seed during germination more difficult or even impossible. I. Roxburghii agrees pretty closely with this type. I. Quamoclit (fig. 539) also agrees with it as far as the invagination is concerned and the length of the lateral lobes of the cotyledons, but the latter are very much folded transversely so that its axial length is considerable, and this is well seen after germination as well as before it. The seed is comparatively small.

I. dasysperma represents the fourth type in which the cotyledons are bipartite. The real length of the midrib, and therefore the lamina, is almost nil; but, on the contrary, we have an unusual development of the lateral lobes. The invagination of the micropyle and the tegmen is considerable. The radicle is long, in fact nearly equalling the length of the seed, bringing the apical sinus in contact with the prominent tegmen. The lamina is little or not at all transversely folded, but the folding is excessive in the long lateral lobes. The basal auricles are moreover well pronounced in this species. Two long lateral nerves traverse the lobes, and there is a third short one at the base. Convolvulus Cneorum might almost constitute a fifth type, so much does it differ from the last. The cotyledons are bipartite, in fact cut into the petiole, and they are folded transversely, but not to any great extent. The invagination of the tegmen is very slight, in fact almost obsolete. That of the micropyle is, however, normal. This divided state of the cotyledons may have arisen in an ancestral form having the inner coat of the seed strongly infolded as in the above cases, and the invagination may have become obsolete in more recent times, while the fission of the cotyledons has persisted. The fission would however favour or facilitate transverse folding, seeing that broad undivided cotyledons would have difficulty in folding into or adapting themselves to the peculiar shape of the seed. The seeds of this species are shortly and densely pubescent; those of Ipomœa dasysperma are silky, those of I. Quamoclit pubescent, of I. Pes-capræ densely so.

The seeds and embryos of Nolana atriplicifolia are built upon quite a different plan and strongly resemble those of a Solanum, a Chenopodium, or their allies. The ovule and seed are campylotropous. The embryo is terete and very much curved or circinate, passing round the periphery of the seed and covered merely by a very thin layer of endosperm, with a greater quantity of the latter in the middle of the seed. The cotyledons are incumbent, plano-convex, and lie in the narrow way of the seed which is angled but slightly compressed.

Seedlings.—The greater number of the seedlings observed are modelled on the same plan, but vary considerably in the depth of fission of the cotyledons, in the number of nerves radiating from the base of the lamina, and in size. Seedlings of the tribe Nolaneæ have cotyledons resembling those of a Solanum. All those noticed may be conveniently divided into five or six groups according to the division of the cotyledons and their venation.

The first group may be represented by Convolvulus Soldanella which has broadly oblong or squarish, shallowly emarginate cotyledons with seven nerves radiating from the base. The hypocotyl is very short and the petioles of the cotyledons greatly elongated. The first two leaves are reniform-orbicular. The cotyledons of C. sepium are very similar but narrower and longer, with shorter petioles and a longer hypocotyl. The shoots proceeding from their axils are geotropic. The first two leaves are cordate and subhastate, acute and widely separated by the lengthening of the internodes. The first and second leaves of a seedling of this species curiously enough were almost the counterpart of the cotyledons, but were rather smaller and more deeply emarginate. Something similar is of frequent occurrence in Ipomœa Pes-capræ; in fact such a form is the most common one. The cotyledons of Convolvulus tricolor are obcordate or cuneate, bifid, trinerved at the base, and remarkably similar to those of Brassica, both in shape and venation. The first five leaves are spathulate, the sixth linear-oblong, and the seventh to the fourteenth inclusive, oblong. The cotyledons of Convolvulus triflorus are similar, but more deeply bifid. The two first leaves are oblong-ovate.

A third type is met with in Ipomœa Pes-capræ which has deeply bifid cotyledons, trinerved at the base as in the last case, while a pair of strong lateral nerves are given off from the midrib higher up, so that two strong lateral nerves traverse each lobe of the lamina. The primary leaves are very variable in different individual seedlings. In the one described the first one is oblong, and seven suceeding ones are oblong-obcordate, or shortly bifid as in the typical leaf of the adult plant which is not unlike the impression made by a goat's foot on the ground, hence the specific name. The leaves of the adult plant in the Kew specimens are more polymorphic than those of the seedling ; they are broader than long, or suborbicular or oblong-emarginate, sometimes subcordate at the base, or they are ovate, or obovate-oblong. The cotyledons of Ipomœa Nil are also trinerved from the base, but they are rather less deeply divided, unequal in size and have wider lobes. The first three leaves are cordate, acuminate, and five-nerved from the base. I. dissecta (fig. 542) has also unequal, trinerved cotyledons, but they are more deeply auricled at the base, and a second pair of lateral veins arise a little above the base making them almost five-nerved. Their petioles are considerably elongated to compensate for the shortness of the hypocotyl above the soil. The first internode of the stem is but little developed, and the first leaf five-toothed and almost or quite rudimentary. The second leaf is five-lobed and several times larger, but yet very small. The third to the sixth inclusive are palmately five-nerved and -partite with rhomboid-lanceolate segments.

A fourth type is exhibited by those species having five to seven nerves proceeding from the base of the lamina. Ipomœa hispida (fig. 541) has cotyledons resembling those of I. Nil in outline and depth of division, but they are more nearly equal, and five-nerved at the base. The first two leaves are cordate, acute and seven-nerved at the base. The cotyledons of I. Roxburghii are larger, rather more deeply bifid, and seven-nerved at the base. The first leaf is cordate, acute, and the next two are similar, but angled at the sides or incipiently lobed. All are five- to seven-nerved at the base. The cotyledons of Argyreia speciosa are remarkably similar to those of Ipomœa Roxburghii. The first leaf is however cordate-acuminate, and the second cordate-acute. The hypocotyl of Argyreia cuneata is subterranean, fleshy, stout and inseparable from the upper part of the root. The cotyledons are faintly seven-nerved at the base, and have long, slender petioles partly buried in the soil. The internodes of the slender, flexuose stem are elongated. The first leaf is broadly oval and rounded at either end ; the following three are more elongated and proportionately narrower. The cotyledons of Lettsomia aggregata are divided more than half-way to the base. The first two leaves are roundly ovate; the second spathulate; and the third obovate, and emarginate. A fifth very distinct group centres around Ipomœa Quamoclit (fig. 540) which has deeply bipartite cotyledons with linear, widely divaricate segments traversed by two nerves each. The real length of the lamina is from the apex of the petiole to the middle of the sinus, and is really very short. The lobes represent lateral growth after the cotyledons can no longer grow in length; they are very much folded transversely while still in the seed. The first two or more leaves are deeply pinnatisect with linear lobes appearing as if pinnate. I. dasysperma closely corresponds to this type, but the leaves are different from those of I. Quamoclit. The cotyledons of I. palmata are scarcely so deeply divided, and are rather irregularly four- to five-nerved at the base, with strongly ascending segments. The first three leaves are cordate, five- to seven-nerved at the base, and trifid at the apex, or they show a few more lateral teeth. The cotyledons of an unnamed, subshrubby, and apparently climbing species of Convolvulus are deeply bipartite with linear one-nerved segments. The first two leaves are lanceolate, while succeeding ones up to the ninth differ chiefly in their much greater length. An extreme limit of division is met with in Convolvulus Cneorum, an upright shrubby species with hoary and silky foliage. The cotyledons are cut or divided, not only to the base of the lamina, but into the petiole, giving rise to four diverging, one-nerved segments resembling as many cotyledons. The first four leaves are oblanceolate, and narrowed into a short petiole.

The simplest type of cotyledons in the Order as far as I have observed is that of the Nolaneæ, whose peculiar characteristics have already been mentioned under seeds. Those of Nolana atriplicifolia (fig. 543) are lanceolate-oblong, fleshy, and indistinctly one-nerved. The first leaf is ovate and the four succeeding ones are more elliptic. The cotyledons of a Nolana from Santiago are narrowly spathulate, petiolate, one-nerved, and pubescent. The first seven or eight leaves exactly resemble the cotyledons in size, length, and hairiness.

Argyreia cuneata, *Bot. Reg.*

Primary root perennial, fleshy, subglobose, smooth, and together with the hypocotyl forming a tuberous rootstock,

Cotyledons equal, with glabrous, green or reddish petioles, 4–·5 cm. long, 1·5 mm. thick, with their basal ends 1 cm. or less below the surface of the ground on the broad collar of the hypocotyl, and surrounding six or more buds in the two axils; lamina 2·5 cm. long and as wide, bilobed, cordate at the base, obtuse at the apices, otherwise entire, palmatinerved, with a short midrib and two primary nerves meeting within the apex of each lobe, glabrous, thin, light green, rather persistent, and presenting a strange appearance through being partly buried.

Stem suberect, firm, terete, pubescent; 1st internode 4–6 cm. long, 1·5 mm. thick; 2nd and 3rd shorter.

Leaves simple, entire (at least in the seedling stage), cauline, alternate, exstipulate, petiolate, alternately incurvinerved, with the bases of the nerves decurrent on the midrib, smooth and deep green above, pubescent on the margin and covered with a silvery or silky tomentum beneath; petioles short, grooved on the upper side.

No. 1. Shortly petiolate, 3·5–4 cm. long, 2·5 cm. wide, oval, rounded at both ends, with entire, pubescent margin, sunk midrib and pinnate nerves, coriaceous, smooth and dark green above, woolly and paler beneath.

Nos. 2–4. Oval, slightly more tapered to both ends and larger, 6–7 cm. long, and 3 cm. wide.

Argyreia speciosa, *Sweet.*

Primary root a long taproot with a large number of long, thick, much branched, white fibres.

Hypocotyl herbaceous, 6–8 cm. long, 2–2·5 mm. thick, terete, pubescent, dull green, purplish about the middle.

Cotyledons long-petioled, about 6 cm. long, 4–5 cm. wide, bilobed, deeply cordate at the base, obtuse at the apex, otherwise entire, with a short forked midrib and two strong primary nerves on each side, sunk and forming a very narrow ellipse in each lobe, quite glabrous, bright green above, paler beneath, thin, somewhat persistent; petioles semiterete, channelled.

Stem herbaceous, short, terete, tomentose; first few internodes about 5 mm. long, and 2–2·5 mm. thick.

Leaves simple, cauline, alternate, exstipulate, petiolate, cordate, alternately incurvinerved, reticulated, glabrous and deep green above, covered with a silky tomentum beneath, conduplicate in bud; petioles hairy, tomentose or woolly, subterete.

No. 1. With a tomentose subterete petiole 3·5 cm. long, and 1·5 mm. in thickness, and a cordate blade 4 cm. long, and 3 cm. wide with deep base and cuspidate apex, plane, pinnatinerved, with entire, pubescent margin, glabrous and bright green above, tomentose and paler beneath, not very thick; vernation conduplicate.

No. 2. Similar but larger.

Lettsomia aggregata, *Roxb.*

Hypocotyl erect, terete, glabrous, very short, about 6–8 mm. long.

Cotyledons bifid for more than half their length with diverging lobes, subcordate at the base, with the midrib very short and bifurcate some distance below the base of the sinus representing the true length of the cotyledon, and giving off two strong and one slender lateral nerve into the ascending and diverging lobes, petiolate, glabrous except the petiole, deep green above, paler beneath; lamina to the base of the sinus 1 cm. long, and the oblong-ovate lobes 1·5–1·6 cm. longer; width from tip to tip of the lobes 2·2 cm.; petiole subterete, channelled and downy above. 1·1–1·3 cm. long.

Stem stout, erect at first, ultimately twining, densely silky or hairy with adpressed hairs; 1st internode 5–8 mm. long; 2nd 3–5 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, irregularly and alternately, ascendingly penninerved, with the ends of the nerves incurved and uniting one with another, subreticulate, densely silky hairy and subhoary on the under side, and pubescent above, deep green and shining with a silky margin; petioles subterete, channelled above, densely silky hairy.

Nos. 1 and 2. Rotund-ovate, obtuse, subcordate at the base.

No. 3. Spathulate, obtuse, entire, cuneate at the base.

Nos. 4 and 5. Obovate, emarginate, cuneate at the base.

Ipomœa Pes-capræ, *Sweet.*

Ovary of two to three carpels, two- to three-celled, four- to six-ovuled; ovules two in each cell, erect from the base of the inner angle of the cell, anatropous; micropyle inferior.

Capsule globose, two- to three-celled, four- to six-seeded, dehiscing by valves.

Seed obtusely trigonous, forming a segment of a sphere, convex longitudinally and transversely on the back, blunter at the basal end, deep brown, almost black, densely pubescent; hilum inconspicuous; tegmen very much invaginated from the inner angle of the seed which is almost divided in two internally; micropyle also invaginated, containing at first the whole embryo, ultimately only the radicle.

Endosperm in the mature seed copious, clear or subtransparent, embedding the embryo, swelling up and mucilaginous in water.

Embryo large, curved, pale yellowish; cotyledons broad, deeply bifid, conduplicated and variously folded or plaited, one half of each lying on each side of the deep invagination of the tegmen; radicle large, curved, lying in the invagination of the micropyle towards or at the base of the dorsal aspect of the seed.

Seedling.

Hypocotyl erect, terete, glabrous, about 1·6–2 cm. above the soil.

Cotyledons deeply bifid with diverging lobes, petiolate, thick and subcoriaceous and more or less shining, glabrous, deep green above, paler beneath, with a midrib reaching nearly to the sinus, and giving off from each side towards the base two strong nerves running nearly to the apex of the lateral lobes where they join; there is often present a third but more slender nerve from each side near the apex which runs along the inner edge of the lobes; lamina about 1 cm. long to the apex of the midrib, and about 2·2 cm. to the apex of the ascending lateral lobes, 2·6–2·8 cm. from tip to tip of the lobes; petiole semiterete, channelled above, glabrous, 6–8 mm. long.

Stem erect at first, terete or slightly furrowed from the base of the petioles downwards, flexuose or zigzag, dull brownish-green, glabrous; internodes often extremely irregular in the early stages of the plant; 1st one undeveloped or 5 mm. long; 2nd 2·5 mm.–2·1 cm.

Leaves simple, cauline, alternate, but often opposite, or irregularly fascicled in the younger state of the plant, exstipulate, petiolate, alternately and ascendingly penninerved, or oppositely nerved towards the base with numerous slender nerves branching and anastomosing with one another within the margin of the leaf, subcoriaceous, glabrous, more or less shining on both surfaces, deep green above, bright green beneath; petioles subterete, slightly channelled above, stout, somewhat decurrent on the stem, dull brownish-green, glabrous, tapering somewhat upwards.

Early leaves very variable in outline.

No. 1. In the specimen described, oblong, obtuse, slightly emarginate.

Nos. 2 and 3. Obovate-oblong, broadly emarginate with a tooth in the notch.

Nos. 4–7. Broadly obcordate, or widely bifid, slightly cuneate at the base, with a tooth in the apical sinus.

The leaves on adult plants are very variable, as the following instances will show.

No. 1. Deeply obcordate, and on the upper part of plant almost transverse, with oblong, obtuse, diverging lobes, having numerous ascending parallel veins—four from the base on each side and a few alternate ones upwards, with the midrib excurrent, much reticulated. The lower leaves were like the cotyledons.

No. 2. Rotund or oblong, emarginate, subcordate or rounded at the base, alternately penninerved with four contiguous pairs at the base; midrib slightly excurrent. Upper leaves broadly subovate, less cordate at the base. The midrib in both these plants was much in advance of the lamina in young unfolded leaves, but it gradually falls behind the lateral lobes as the leaf becomes ready to unfold.

No. 3. In another form the leaves were ovate or obovate-oblong, retuse, rounded or emarginate, and apiculate, irregularly alternately penninerved, more or less cuneate or wavy at the base, and having the midrib excurrent at the apex in all cases.

Ipomœa purpurea, *Lam.*

Ovary surrounded at the base by an annular, hypogynous disc, of three carpels, three-celled, two ovules in each cell; ovules as in I. Pes-capræ.

Capsule globose, even and glabrous externally and internally, three-celled, two- to six-seeded, and containing the remains of the aborted ovules when less than six-seeded, tipped with the conical remains of the persistent style, dehiscing by three valves.

Seeds when six occupying the whole fruit, trigonous with the two outer angles acute, the inner one blunt, and the lateral faces flat and much broader than the dorsal aspect which is convex or rounded, both longitudinally and transversely, pale whitish, ultimately deep brown, rounded at the extreme base which projects a little beyond the hilum; hilum orbicular with a basal notch, brown before the seed is mature, seated on an oblique depression of the seed facing the inner angle of the cell. Where two seeds only occupy the fruit, they are ovoid or more or less hemispheric, occupying two cells of the ovary, while the third is nearly squeezed up close to the outer wall.

Endosperm plentiful, like a transparent jelly, occupying all the interior of the unoccupied space in the growing seed and surrounding the embryo, ultimately becoming dry and cartilaginous, occupying the space between the folds and wrinkles of the mature embryo, and still transparent where quite thin, mucilaginous and swelling up considerably when placed in water.

Embryo quite straight at first and lying in the conical hollow process near the hilum which forms a passage for the radicle to the micropyle ; but later on as growth proceeds the cotyledons are projected beyond this process and commence to become concave towards the inner angle of the seed. They soon become doubled sharply over the end of the process, extending to the apex of the seed and both doubling over and abutting against the prominent ingrowth of the tegmen, become deeply bifid at the apex, more or less cordate at the base, and much wrinkled.

Ipomœa Quamoclit, *L.* (fig. 539).

Ovary of two carpels, two-celled or by the interposition of spurious septa four-celled; ovules as in I. Pes-capræ.

Fruit a capsule.

Seed trigonous, flat on the sides in contact with the others, rounded on the dorsal aspect both longitudinally and transversely, deep brown almost black, pubescent; hilum small, brown, facing the placenta obliquely; tegmen invaginated rather deeply but squeezed down by the growing embryo, so that in cross-section it resembles the letter ⊤.

Endosperm in the mature seed forming a layer surrounding the embryo, subtransparent, becoming mucilaginous when placed in water.

Embryo large, conduplicate and curved, pale yellowish; cotyledons large, foliaceous, bifid, cordate at the base, bent back at the end of the invagination of the micropyle and doubled in beneath it, then recurved upwards and proceeding to the apex of the seed; radicle subfusiform or cylindrical, obtuse, curved towards the

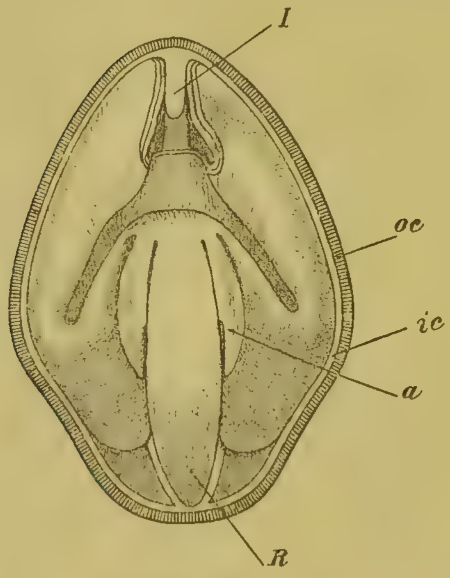

Fig. 539.—*Ipomœa Quamoclit*, × 18.
Seed laid open, showing the dorsal face of the embryo *in situ* : *I*, invagination of the tegmen; *oc*, testa, and *ic*, tegmen of seed; *a*, auricles of cotyledons; *R*, radicle.

micropyle, following the outline of the basal and dorsal aspect of the seed.

Seedling (fig. 540).

Primary root a short, succulent taproot, with a few branched, colourless, fibrous lateral rootlets.

Hypocotyl herbaceous, about 6 cm. long, 1 mm. thick, two-furrowed, from the decurrent bases of the petioles of the cotyledons, glabrous, bright green.

Cotyledons very short but transversely linear, 3·5–5 cm. long from tip to tip, the broadest part about 4 mm. and the middle 3 mm. wide, cordate at the base, rather obtuse at the apex of each lobe, with a midrib 1 mm. long, giving off two strong lateral nerves on each side running parallel for some distance, and the upper one to the apex of the lobes, glabrous, pale green in the earlier stage, with undulate entire margin, thin, somewhat persistent.

Stem herbaceous, suberect, furrowed, glabrous, shining, light green; the first few internodes about 5 mm. long, 1 mm. thick.

Leaves uni- to bi-pinnatisect, deep green, glabrous, with slender linear segments.

No. 1. About 3·5 cm. long, 2 cm. wide, with a glabrous petiole 7·5 mm. long and ·75 mm. thick, distinctly pinnatisect, with the lowest pair of segments shortly bipinnatisect, the other three pairs with the terminal segment narrowly linear, about 1·5 cm. long, 1·25–1·5 mm. wide, acuminate, glabrous, dark green, with sunk midrib.

No. 2. Similar, with five pairs of segments, most of which are bipinnatisect.

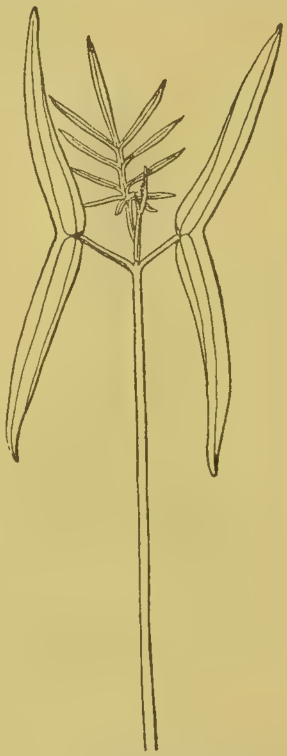

Fig. 540.—*Ipomœa Quamoclit.* Nat. size.

Ipomœa hispida, *Roem. et Schult.* (fig. 541).

Primary root long, with a few branched white fibres.

Hypocotyl herbaceous, suberect, about 6 cm. long, 2 mm. thick, terete, glabrous, with decurrent lines from the base of the cotyledons, green with a light purplish hue.

Cotyledons unequal, with petioles 3·5–4·5 cm. long, 2–3 cm. wide, quadrangular, bilobed, cordate at the base, rounded at the apex of each lobe, five-nerved at the base or, more correctly, giving off two strong primary nerves from each side of the midrib, the latter terminates in a small fork near the sinus, and the nerves become incurved and join near the apex of the lobes; strong secondary nerves are given off from the basal pair of primary ones; reticulated, quite glabrous, thin, yellowish-green above, paler beneath.

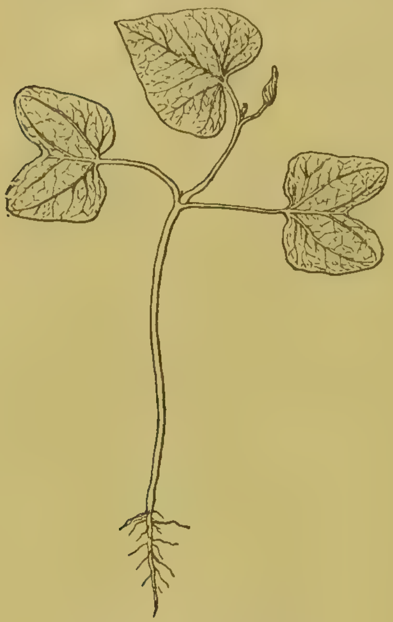

Fig. 541.—*Ipomœa hispida.* Half nat. size.

Stem herbaceous, twining, with long internodes about 1 mm. thick, terete, pubescent, with deflexed hairs, pale green.

Leaves alternately incurvinerved or radiately at the base, reticulate, more or less pubescent, deep green above, paler beneath.

Nos. 1–3. Long-petioled, simple, 3·5–5 cm. long, cordate or subcordate, acute, entire, palmatinerved at the base, alternately nerved along the midrib, slightly pubescent, thin, bright green above, paler beneath; petiole slightly pubescent, pinkish.

Ipomœa Roxburghii, *Steud.*

Ovary as in I. purpurea.

Capsule dehiscing by the three valves separating from the septa, almost invariably six-seeded; valves thin, rather brittle, pale brown.

Seeds trigonous, testa rather cartilaginous when dry, pale or dirty white, with the micropyle close to the round basal hilum, which faces obliquely the inner angle of the cell, somewhat marked by the crumpled cotyledons within.

Endosperm surrounding the large embryo, colourless while the seed is yet immature, afterwards cartilaginous when dry, thin and membranous at places where the cotyledons press upon it, and forming larger solid masses between the folds of the embryo.

Embryo large, green at first and becoming dirty white when mature and dry; cotyledons deeply bifid, cordate at the base, five-nerved, with the midrib becoming forked a little below the sinus, one fork entering each lobe, superposed face to face, and then doubled longitudinally, the midrib and radicle following the curved back of the seed and the lateral margins of the cotyledons turned towards the inner angle, at first merely convex on the back and concave on the inner side, but ultimately becoming much crumpled transversely; radicle lying in a grooved process attached close to the micropyle on the dorsal aspect.

The sinus of the cotyledons seems to facilitate their doubling upon each other longitudinally, or may even be the effect of that act and the intrusion of the tegmen, for the lobes become longer and more developed as the seed progresses to maturity; the whole embryo which is very large conforms to the shape of the seed which with its fellow shares equally one cell of the ovary, while the six seeds fill the globose capsule.

Seedling.

Primary root nearly vertical, a short taproot, with long, colourless, branched fibres.

Hypocotyl herbaceous, 6–8 cm. long, 2–2·5 mm. thick, terete, glabrous, seldom slightly pubescent, bright green.

Cotyledons seven-nerved at the base, 3·5–4·5 cm. long, 3·5–4 cm. wide, pubescent otherwise like those of I. hispida.

Stem herbaceous, suberect, terete, pubescent, the rather long hairs pointing downward; first few internodes about 1·5 cm. long, 1·5 mm. thick.

Leaves.—No. 1. Long-petioled, 5–6 cm. long, 3–4 cm. wide, cordate, acuminate, entire, radiately incurvinerved at the base, and alternately along the midrib, pubescent all over, thin, bright green above, paler beneath.

No. 2. Similar, but the apex cuspidate with one small lateral lobe.

No. 3. Similar, but slightly trilobed.

Ultimate leaves simple, cauline, alternate, exstipulate, petiolate, radiately incurvinerved at the base, and alternately upwards, reticulate, pubescent all over, membranous, bright green above, paler beneath; petioles rather slender, semiterete, channelled above, pubescent or hairy.

Ipomœa Nil, *Roth.*

Hypocotyl suberect, herbaceous, 6–9 cm. long, 1·5–2 mm. thick, terete and reddish near base, ridged and pale green higher up, glabrous.

Cotyledons like those of I. Roxburghii in size and shape, but only trinerved, and sometimes asymmetrical.

Stem herbaceous, terete, glabrous, shining light green; 1st internode 1 cm. long, 1·5 mm. thick; 2nd 3 cm. long, 1 mm. thick; next longer and thinner.

Leaves.—No. 1. About 8 cm. long, 3 cm. wide (including the channelled glabrous petiole), cordate or subcordate, acuminate or cuspidate, entire, palmately incurvinerved, glabrous, thin, light green.

No. 2. Narrower in proportion to its length.

Ultimate leaves as in I. Roxburghii, but glabrous.

Ipomœa dissecta, *Willd.* (fig. 542).

Hypocotyl above ground very short, stout, fleshy, glabrous, pale or colourless.

Cotyledons foliaceous, very large, bifid for more than half their length, very broad transversely, with broadly oblong, obtuse, divaricate lobes, cordate at the base, glabrous, deep green, petiolate; venation consisting of a slender median nerve, bifurcate near its apex, and giving off a strong lateral nerve on each side near the base, and a stronger pair at the base of the lamina, and all four with ascending branches which again divide more or less; larger lamina 1·15 cm. long, 3·9 cm. wide (each lobe 2·7 cm. long); smaller lamina 1·1 cm. long, 3·6 cm. wide (each lobe 2·5 cm. long); petioles unequal, semiterete, channelled above, glabrous, purplish, the longer 5 cm. long, the shorter 4·1 cm. long.

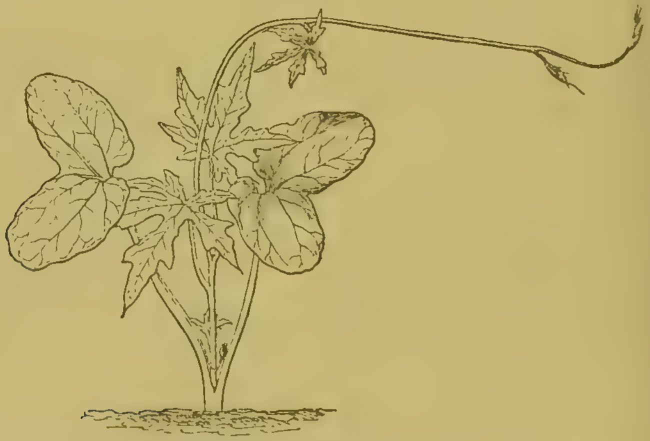

FIG. 542.—*Ipomœa dissecta.* Half nat. size.

Stem herbaceous, erect, soon twining, terete, glabrous, marked with small distant, papillose elevations, pale purplish; 1st internode 3 mm. long ; 2nd hardly developed ; 3rd 1·8 cm. ; 4th 5 mm. ; 5th 6·2 cm.

Leaves palmately five- to seven-nerved and -lobed, glabrous, light green ; petioles slender, nearly terete, slightly channelled above, glabrous, pale green or tinted with purple.

No. 1. Very small, almost rudimentary, five-fid or -toothed.

No. 2. Much larger, but still very small, palmately five-lobed ; middle lobe much the largest ; basal smallest.

Nos. 3–6. Palmately five-sect with the basal and smallest lobes again divided on the posterior side into a more or less distinct lobe ; middle lobes rhomboid-lanceolate, acute, alternately penninerved and subreticulate, with a few irregular sized teeth, about the middle on each side—middle lobe largest, but similar to the rest in shape and margin.

Ipomœa palmata, *Forsk.*

Hypocotyl 2–3 cm. long, about 2 mm. thick, terete, smooth near the base, somewhat warty under the cotyledons, herbaceous, purplish-brown.

Cotyledons with glabrous, channelled, purplish-green petioles 1 cm. long, 1·25 mm. thick ; lamina deeply bifid, 2·5 cm. long, with a short midrib forking a little below the sinus, and giving off two, rarely three, primary nerves into each lobe, running nearly parallel to each other, without distinct union within the apex of the lobe, glabrous, thin, light green, paler beneath, somewhat persistent.

Stem short, terete, slightly scabrous or warty, herbaceous, purplish ; first few internodes 2 mm. long, 1·25 mm. thick.

Leaves radiately incurvinerved at the base, alternately nerved upwards, and reticulate, glabrous, membranous, light green above, paler beneath ; petioles rather long and slender, subterete.

No. 1. With channelled, glabrous, purplish petiole 3 cm. long, 1 mm. wide, and a broadly cordate blade, 2·5 cm. long, and as wide, acuminately trifid at the apex, obtusely angled near the cordate or subcordate base, with seven radiately incurving nerves, glabrous thin, yellowish-green above, paler beneath.

No. 2. Similar.

No. 3. Similar, but more palmatifid.

No. 4. Nearly palmatilobed, all the lobes being mucronate-acuminate.

Convolvulus sepium, *L.*

Pistil surrounded at the base by an annular disk ; ovary of two carpels, two-celled or by the early rupturing of the septum one-celled, four-ovuled, sessile; ovules erect, inserted at some distance from the centre of the fleshy placentas which occupy all the base of the ovary, anatropous, the raphe running along the inner angle and forming a stout ridge in the upper interior half of the ovary; radicle next the hilum but on the dorsal aspect.

Fruit a capsule, globose, tipped by the persistent remains of the style, one-celled, two- to four-seeded, pale brown, brittle, glabrous externally, silky with adpressed pubescence internally.

Seeds trigonous when four are matured, with the lateral faces flat, or more or less shrunk or somewhat wrinkled, and the dorsal aspect longitudinally and transversely convex or rounded, obtusely and minutely tridentate at the base of the dorsal aspect, the radicle close to the middle tooth containing the micropyle, nearly white, ultimately brown, glabrous, albuminous; hilum reniform, on the oblique basal scar with the convex side towards the inner angle.

When two seeds mature, even if in the different though undivided compartments of the ovary, they share the space and become nearly or quite hemispheric.

When one seed only is produced it becomes ovoid or subglobose and variously but obtusely angled.

Endosperm plentiful, of a clear jelly-like consistency and mucilaginous when the seed is in a growing state and completely surrounding the embryo. As the seed matures it diminishes, adapting itself to the various wrinkles and folds of the embryo, at the same time becoming hard and horny, but preserving a clear colour where still thin and membranous.

Embryo straight at first with flat cotyledons which ultimately become very large and variously wrinkled, adapting themselves to the internal construction of the seed. When the embryo is only 2 mm. long and 1·5 mm. broad, it is nearly, if not quite, straight and flat; the cotyledons are rotund, entire, and trinerved, and the whole embryo is embedded in jelly-like endosperm and rests in an invagition of the micropyle, which increases in size with the embryo. The cotyledons project beyond this and become at first concave towards the inner angle of the seed; they soon become much concave and slightly emarginate, doubling sharply over the point of the supporting process, and down behind it where the liquid endosperm offers no resistance. The cotyledons up to this stage are green. As they attain full size they become much wrinkled, and pale yellowish or dirty white. They have previous to this ultimate stage grown to the full length of the seed, and the shallow notch in the cotyledons abuts against a ridge at the apex of the seed formed by the invaginated tegmen extending some way down the interior of the dorsal aspect of the seed where it becomes shallow and extends to the hilum. Hence the notch in the cotyledons is caused by their growing at the sides after their apex has reached this ridge.

Seedling.

Primary root elongated, tapering, with numerous lateral branching fibres.

Hypocotyl erect, terete, glabrous, green or purplish, stout, 7–15 mm. long.

Cotyledons large, foliaceous, broadly oblong, truncate and shallowly emarginate above, truncate or abruptly cuneate at the base where they are five-nerved, alternately nerved upwards; nerves strong, forking, the midrib generally though not always proceeding to the tip, sometimes forking a little way below it, light green, glabrous; lamina 2–2·8 cm. long, 1·9–2·65 cm. wide; petiole semiterete, channelled above, 2 to 2·5 cm. long.

Stem herbaceous, at first erect, afterwards twining from right to left or against the sun, above the first or second true leaf, terete, glabrous, twisted after commencing to twine; internodes very variable, 1st 3·4–6·5 cm. long; 2nd almost undeveloped to 3 cm.; the rest longer.

The first two branches originating in the axils of the cotyledons are geotropic, deep red, and resolve themselves into underground rhizomes or creeping stems, with small scale-like leaves. If the main axis should by any accident be broken off, the branches from the cotyledons assume the appearance and characters of the primary stem, and perform the same functions.

Leaves simple, cauline, alternate, exstipulate, petiolate, glabrous, light green, five-nerved at the base, alternately nerved upwards with somewhat incurved, anastomosing nerves; petioles semiterete, glabrous, channelled above, frequently twisted at the base to bring the blade of the leaf to the light.

No. 1. Cordate-subhastate, cuspidately acute, with the lower pair of lateral nerves running into the obtuse angles.

No. 2. Cordate, elongated, cuspidately acute or having an odd, obtuse angle on one side.

Nos. 3 and 4. Cordate, elongated, cuspidately acute.

These characters are liable to variation, and sometimes all the early leaves are simply elongated-cordate. In one specimen noted the first two leaves were exactly like the cotyledons, but smaller and rather more deeply emarginate.

Ultimate leaves hastate or sagittate, always with a deep basal sinus, obtuse or acute with the basal lobes frequently angled or obtusely dentate.

Convolvulus Soldanella, *L.*

Fruit, seeds, and embryo similar to those of C. sepium; seeds a deep, dull, purplish-black colour.

Seedling.

Hypocotyl short, subterranean, gradually and indistinguishably tapering into the root.

Cotyledons very similar to those of C. sepium, but rather wider and with longer petioles.

Stem herbaceous, erect, terete, marked with two raised, somewhat muricate lines running down from the base of each leaf, one on each side, green, heavily mottled with purple in the young stage, glabrous, ultimately procumbent, trailing or slightly twining, considerably twisted, pale green and mottled with pale purple; internodes variable; 1st 3–8 mm. long; 2nd 3·5–4·5 mm.; 3rd 4·5–10 mm. Ultimate ones 2–3 cm.

Leaves exstipulate (or adult ones with stipule-like excrescences at the base of the petiole which are constant), trinerved from the base, each nerve branching considerably on the lamina of the leaf; petiole as in C. sepium.

Nos. 1 and 2. Reniform-orbicular, minutely emarginate, otherwise entire or rarely incipiently angled at the sides towards the base, cuneate in the basal sinus, deep green, shining.

Ultimate leaves reniform, shortly cuspidate, shallowly and obtusely angled at the ends of the principal nerves and shallowly crenate between, cuneate in the basal sinus, the three primary nerves much branched, giving rise to reticulate venation.

Convolvulus tricolor, *L.*

Capsule two-celled, one- to four-seeded, pale brown, brittle, dehiscing by the separation of the valves from the septum.

Seed where four occupy the capsule obtusely trigonous, forming the fourth part of a sphere, equal at the base, muricate or covered with little elevations on all sides, pale whitish, ultimately brown; hilum oblong-subreniform, small, seated about the centre of the small horizontal depression at the base of the seed, with the slightly convex side to the inner angle.

Endosperm thin and membranous where in close contact with the folds of the embryo, but forming masses in the unoccupied spaces, swelling up and becoming mucilaginous in water.

Embryo straight in the early stages and lying in a truncate, hollow invagination of the micropyle, becoming curved at an early period, after the cotyledons project beyond the hollow process, then becoming concave on the side towards the axis of the ovary; as growth proceeds it reaches the apex of the seed and then becomes sharply doubled transversely over the end of the supporting process where there is no resistance. After this it extends to the inner angle of the seed with its edges on each side of the slightly prominent invagination of the tegmen. The cotyledons become transversely oval and slightly emarginate at a very early age, a shape which they retain to the last, and are deep green from the time they become visible till mature, when they become pale yellow; radicle in the mature embryo at right angles to the midrib of the cotyledons.

Convolvulus tricolor, *L.*, *var.* robustus unicaulis.

Primary root long, flexuose, with numerous lateral rootlets, annual.

Hypocotyl erect, terete, thickened under the cotyledons, glabrous, a deep blood-purple.

Cotyledons obcordate, suddenly tapering at the base, trinerved, subcoriaceous, glabrous except the petiole, which is channelled above and slightly pubescent on the margins of the channels, and dull blood-purple; lamina green, 1·45 cm. long, 1·55 cm. wide; petiole 1·5 cm. long.

Stem herbaceous, annual, erect, terete, pubescent, deep blood-purple at the base and green upwards; 1st internode 6 mm. long; 2nd undeveloped; 3rd 6·5 mm.; 4th 4·5 mm.; 5th 9 mm.; 6th 7·5 mm.; 7th 9 mm.; 8th 9 mm.

Leaves simple, entire, cauline, alternate (first two opposite or subopposite), exstipulate, sessile, sparsely villous when young, ultimately glabrous or minutely pubescent, with a median nerve and a few lateral, alternate, ascending nerves.

Nos. 1 and 2. Opposite or subopposite, spathulate, rounded at the end and tapered to a long, narrow, petiole-like base.

Nos. 3–5. Spathulate, obtuse, narrowed to the base.

No. 6. Linear-oblong, cuspidate, not much narrowed to the base.

No. 7. Oblong, acuminate, acute, with a broad base.

No. 8. Oblong, cuspidate, broadest about the middle.

Nos. 9 and 10. Broadly oblong, obtuse, apiculate, broad and subcordate at the base.

Nos. 11–14 inclusive. Oblong, acute, rounded at the base.

Convolvulus Cneorum, *L.*

Ovary of two carpels, two-celled, four-ovuled; ovules ascending or erect, anatropous; micropyle inferior.

Capsule one-celled by the early rupturing of the septa, ovoid or subglobose, membranous, dehiscing irregularly, one- to two-seeded.

Seed ovoid, somewhat pointed, angled, slightly prolonged and truncate on the posterior basal side, deep brown, shortly and densely pubescent; hilum small, round, facing the basal placenta obliquely; chalaza inconspicuous; tegmen thin, membranous, white.

Endosperm clear, subtransparent, surrounding the embryo and filling up the interstices, mucilaginous and swelling up when placed in water.

Embryo large, twice folded, or once folded when the upper third is reversed upon the middle one, embedded in the endosperm, pale yellow; cotyledons shortly petiolate, bipartite or cut into the petiole, with oblong, obtuse, one-nerved lobes; one lobe of each cotyledon lies on either side of the median line of the seed; radicle large, curved, tapering to an obtuse point, incumbent, lying in an ovate process of the micropyle.

Seedling.

Hypocotyl erect, terete, glabrous, colourless, about 1·85 cm. above soil.

Cotyledons bisected to the petiole with oblong, obtuse, diverging segments, each with a central midrib, uniting with one another in the common petiole at or above its middle, alternately penninerved, narrowed at the base to a secondary petiole, glabrous, pale, somewhat greyish-green above and covered with minute scales, pale, but clearer green beneath and minutely scaly; lamina 1·3–1·45 cm. long, 4·5–5 mm. wide; primary petiole semiterete, channelled above, glabrous, pale green, 3·5–4 mm. long; secondary petiole 1–1·5 mm. long.

Stem becoming shrubby, erect, terete, thinly hairy in the seedling, pale green; 1st internode 9·5 mm. long; 2nd 3·75 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, alternately penninerved; nerves incurving, hoary and silky on both surfaces with adpressed hairs; petioles semiterete, short, channelled above, covered with adpressed silky hairs.

Nos. 1–4. Oblanceolate, cuspidate, narrowed into the petiole.

Nolana atriplicifolia, *Don.*

Ovary of five, rarely ten, carpels, one- to four-ovuled; ovules campylotropous; micropyle inferior.

Capsule few-seeded.

Seed variously angled and shaped, rather compressed laterally, 3–3·5 mm. in diameter ; testa slightly rugose, thick, almost corky ; hilum rather conspicuous.

Endosperm fleshy, copious, white.

Embryo curved or rounded on itself, embedded in endosperm ; cotyledons long, linear, circinately curved, obtuse, plano-convex, lying the narrow way of the seed with their faces to the axis, not much wider than the radicle ; radicle obtuse, terete, incumbent on and about as long as the cotyledons.

Nolana atriplicifolia *var.* subcærulea (fig. 543).

Primary root long, tapering downwards, stout, with slender lateral rootlets.

Hypocotyl very short, suddenly tapered into and indistinguishable from the root, colourless.

Cotyledons lanceolate-oblong, obtuse, with a very indistinct midrib, flattened above and convex beneath, fleshy, tapered to a short petiole, glabrous, light opaque green, fading to yellow with age ; lamina 7·5–10·5 mm. long, 2·5–3·25 mm. wide ; petiole ·5–1 mm. long, connate at the base round the plumule.

Stem developed when about to flower ; primary internodes undeveloped.

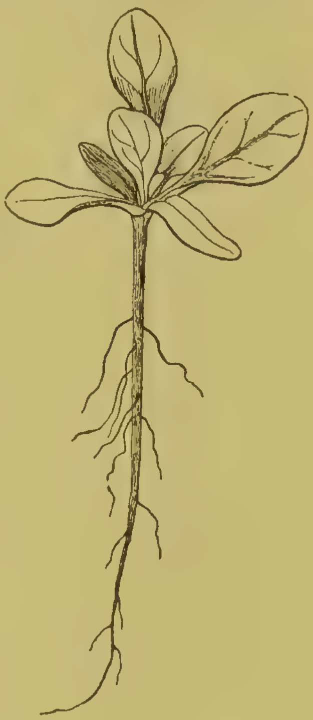

FIG. 543.—*Nolana atriplicifolia* var. *subcærulea*. Nat. size.

Leaves simple, entire, radical and cauline, alternate, exstipulate, petiolate, fleshy, flat or convex above, glabrous except towards base of the petiole, indistinctly alternately incurvinerved, venation best seen on the under side of young leaves, light yellowish-green above, paler beneath ; petioles semiterete, channelled or shallowly grooved above, dilated towards the base and thinly hairy.

Nos. 1 and 2. Ovate, obtuse, somewhat convex above.

Nos. 2–5 inclusive. Subelliptic, obtuse, flattened above or slightly convex.

Nolana sp.

Hypocotyl erect, terete, glandular-pubescent, pale green, 1·5–2 cm. long.

Cotyledons narrowly spathulate, obtuse, glandular-pubescent, petiolate, subfleshy with an indistinct midrib, but no other nerves discernible, pale green, 1·6–1·9 cm. long including petiole, 3–3·5 mm. at the widest, similar to the primary leaves in every respect.

Stem erect, terete, herbaceous, ultimately shrubby, glandular-pubescent, pale green ; primary internodes irregular, short.

Leaves simple, cauline, alternate, exstipulate, petiolate, glandular-pubescent on both surfaces, subfleshy, pale green, with a midrib slightly sunk on the upper, and slightly prominent on the under surface, no other nerves discernible in the seedling stage, tapering into the petiole ; petiole slightly channelled above, similar to the tissues of the leaf and similarly pubescent.

Nos. 1–17 inclusive. Narrowly spathulate, obtuse, entire, somewhat convex above and concave beneath, narrowed insensibly into the petiole.

SOLANACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 882.

Fruit and Seed.—The ovary is superior and two- or rarely three- to five-celled or four-celled by the development of spurious septa as in Datura Stramonium and others. The ovules are nearly always very numerous in each cell and attached to large peltate, or massive, solid, and fleshy axile placentas; they are also arranged in many series, and anatropous or sometimes amphitropous. Sometimes but rarely they are few, and very rarely solitary and fixed to the middle of the septa. The fruit is very often baccate, but is sometimes capsular, dehiscing circumscissly above the middle, or septicidally by two entire or bifid valves, leaving the placentas naked or cohering more or less with them. The seeds are mostly very numerous, with a membranous or crustaceous rugose or sometimes almost muricate testa; more rarely the testa is dilated into a wing surrounding the seed. A fleshy endosperm is present. The embryo is most frequently narrow, terete, strongly incurved, circular, or subspiral with cotyledons shorter than the radicle and in the more typical members of the Order not broader than it. In the Cestrineæ and the Salpiglossidæ the embryo is straighter, more central, and the cotyledons are often considerably broader than the radicle. The radicle is generally close to the hilum. Some abnormal forms occur in the Order such as Nicandra and Jaborosa, as well as a few species and varieties belonging to other genera in which the ovary is three- to five-celled.

The two cells of the ovary are subdivided by the development of spurious septa in Datura, Solandra, and Grabowskia. The ovules are few in the last named genus and solitary in each cell of Sclerophylax, the latter being very anomalous in other respects, including the one- to two-seeded indehiscent fruit. The fleshy fruit of Grabowskia contains four woody pieces, each with one or two seeds. The capsules of Hyoscyamus, Scopolia and Physochlaina dehisce by an operculum. The fruits of some species of Cestrum, Lycium and Retzia are baccate and contain but few seeds or sometimes only one.

Two leading types of embryo are met with in the Order, namely, the subperipherical and more or less curved form, and a nearly straight flat embryo. A very common type is that represented by Datura Stramonium which has a terete embryo surrounding the periphery, but slightly within the endosperm of the flattened and reniform-orbicular seed. The semiterete cotyledons lie in the narrow plane of the seed which has a crustaceous testa. The hilum is situated in a deep cavity at the base of the seed. A transverse section shows the radicle and the cotyledons, the latter being cut through once or twice. A similar section of Solanum Dulcamara often shows the radicle cut through twice, and the short cotyledons only once. S. capsicastrum has an embryo considerably less curved, and the reniform and much compressed seed is girt by a woody mass on each edge. The flattened and reniform seed of Datura Stramonium may be compared with that of Barleria repens which has a large embryo with flattened orbicular cotyledons. The seed of the latter is orbicular, exalbuminous, and belongs to the Acanthaceæ. The seed of Nicotiana rustica is subreniform, and contains an embryo much less curved and forming only a semicircle.

The seed of Cestrum fasciculatum is amphitropous and dorsally much compressed. It contains a nearly straight embryo with broadly ovate or subtriangular cotyledons. The terete radicle is slender and nearly twice as long as the cotyledons. The seed is attached ventrally to the placenta, and is more or less angled by mutual pressure with its fellows.

Seedlings.—The cotyledons are all of simple types and vary from subulate to linear, lanceolate, oblong, ovate, oval, and suborbicular. Species with emarginate cotyledons occur only where the latter are short and broad. The commonest type is lanceolate or narrowly oblong in accordance with their shape while yet in the seed.

One of the most typical forms is represented by Lycopersicum esculentum and Solanum Fontanesianum (fig. 544) which have lanceolate cotyledons. In the first named the cotyledons are hairy and one-nerved. In S. Fontanesianum they are glabrous with the exception of the petiole. The cotyledons of S. Jacquinii are more broadly lanceolate, indistinctly penninerved and finely pubescent. A species of Capsicum (fig. 545) is notable for the great size of its cotyledons, the length of the petiole, and the three pairs of nerves in the lamina ascending at an acute angle.

A slightly different form is met with in Solanum Dulcamara which has narrowly oblong, obtuse, one-nerved cotyledons. The widest cotyledons noticed are those of Solanum quitoense, which are broadly ovate and glandular-hairy on both surfaces.

The cotyledons of species belonging to the tribes Cestrineæ and Salpiglossidæ present a number of short, wide, and often emarginate cotyledons more characteristic of the Scrophularineæ than of the Solanaceæ proper, and owe their shape in great part to that of the seed. Where emarginate cotyledons occur they probably owe this modification to growth. Browallia elata (fig. 549) presents a type very unlike the rest of the Order. The cotyledons are oblate, that is, transversely oblong. They are also very small, one-nerved and distinctly emarginate. The first two leaves are small, oblong-ovate, deeply and bluntly serrate.

Lycopersicum esculentum, *Miller.*

Primary root tapering vertically downwards or diverging at an obtuse angle, giving off lateral adventitious rootlets.

Hypocotyl variable in length, 3 cm. or more, 1·5 mm. thick, terete, coarsely pubescent or hairy.

Cotyledons oblanceolate-linear, obtuse, entire, tapering towards the broad clasping base, 3·3 cm. long, 3–4 mm. wide, hairy.

Stem terete, coarsely hairy, about 1 mm. thick when showing two leaves above the cotyledons, but rapidly becoming much stouter; 1st internode 8 mm. long; 2nd almost suppressed, thus bringing the first two leaves nearly, but not quite, opposite; 3rd and 4th gradually longer.

Leaves cauline, alternate, exstipulate, petiolate, more or less pinnatisect, coarsely hairy and glandular-rugose.

No. 1. Unequal at the base, consisting of a large terminal unequally trilobed segment, and a small, oval, entire, obtuse lateral one.

No. 2. More perfect; terminal segment ovate, trilobed; lobes obtuse; basal pair small, lanceolate.

No. 3. Pinnately trisect; terminal segment triangularly ovate, shallowly trilobed, subcordate at the base; lateral segments narrowly ovate, obtuse, cordate at the base and falcately curved, entire.

No. 4. Pinnately four-sected; the terminal and the lowermost segments solitary.

No. 5. Pinnately five-sected; basal pair of segments small, ovate, entire, obtuse, cordate at the base; middle pair ovate, elongate, entire, obtuse, cordate at the base; terminal segment ovate-elongate, obtuse, shallowly lobed, somewhat twisted towards the top.

No. 6. Similar; the two lateral pairs ovate, obtuse, entire, unequally subcordate at the base; terminal one much larger, ovate, elongated, obtuse, shallowly lobed and somewhat involute at the margins longitudinally on the upper entire part; petiole terete, stout, furrowed somewhat on the upper side.

Stem, leaves and petioles are covered with two kinds of hairs at least in the younger state; longer hairs coarse and non-glandular; shorter hairs fine and tipped with glands.

Ultimate leaves irregularly and interruptedly pinnatisect; segments stalked, not articulate (therefore not pinnate), obtuse or subacute, opposite; lowest pair usually small, ovate, entire; second pair oblong, ovate, pinnatifid or coarsely dentate; third pair very small, ovate, scarcely opposite; fourth pair oblong-ovate, shallowly lobed, very unequal at the base; fifth pair very small, oval, alternate; terminal leaflet or segment oblong, pinnatifid.

The adult leaves, moreover, are extremely variable in size in the division of the lamina as well as its component parts. This variation depends greatly on the luxuriance of the plant or otherwise, brought about by cultivation.

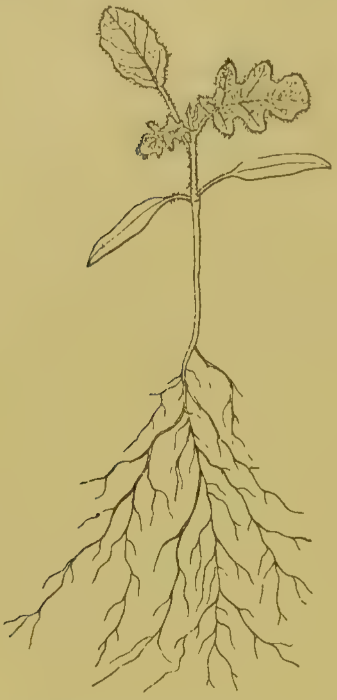

FIG. 544.
Solanum Fontanesianum.
Two-thirds nat. size.

Solanum Fontanesianum, *Dun.* (fig. 544).

Primary root slender, oblique, colourless, with many slender, branched, fibrous, lateral rootlets.

Hypocotyl succulent, 2 cm. long, 1 mm. thick, terete, glabrous, colourless, with the petioles of cotyledons forming a kind of sheath around the base of the stem.

Cotyledons stalked, 1·5–2 cm. long, 4 mm. wide, lanceolate, tapering to the base, acute at the apex, glabrous except the pubescent petiole, with sunk midrib, succulent although thin, yellowish-green, not very persistent.

Stem succulent, terete, ciliate, colourless; 1st internode 5 mm. long, 1 mm. thick.

Leaves simple, cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved, pubescent, hairy, setose and bristly or subspiny, membranous, pale green; petiole semiterete, channelled above, hirsute.

No. 1. 2·5 cm. long, 7·5 mm. wide, oblong, oblique and cuneate at the base, rounded at the apex, with a sinuate margin, alternately penninerved, hirsute, pubescent, thin, light green; petiole 1·25 cm., semiterete, shallowly channelled, pubescent or ciliate.

Nos. 2 and 3. Similar, but scolloped or repandly pinnatifid, and showing a few spines on the midrib and primary nerves.

Solanum Dulcamara, *L.*

Primary root tapering finely, flexuose, with a few similar rootlets.

Hypocotyl as in last species, but dull green, ultimately woody.

Cotyledons oblong, obtuse, tapering to the base, glabrous; lamina 1·4 cm. long, 5·5 mm. wide; petiole somewhat grooved above, 5 mm. long.

Stem erect at first, ultimately decumbent or trailing, flexuose, succulent, ultimately woody, dull green, pubescent; 1st internode 4 mm. long; 2nd 5 mm.; 3rd 5 mm.; 4th 6 mm.

Leaves thinly pubescent and ciliate, ultimately glabrescent except at the margin, where the hairs are more persistent; petioles channelled on the upper side tapering downwards from their point of insertion.

No. 1. Ovate, entire, obtuse, cuneate at the base.

No. 2. Cordate-ovate, obtuse, entire, having ascending incurved nerves.

No. 3. Cordate-ovate, slightly unequal at the base, obtuse.

No. 4. Ovate, acute, unequal at the base.

Ultimate leaves more or less pubescent but variable, cordate-ovate, subacuminate, obtuse, equal or unequal at the base; other forms are triangular-ovate, acuminate, obtuse, deeply pinnatifid at the base with two to three basal lobes, and a large, ovate, acuminate, terminal lobe; lateral lobes obliquely oblong, or ovate, obtuse, binerved.

Solanum giganteum, *Jacq.*

Hypocotyl finely pubescent, light green or colourless.

Cotyledons ovate lanceolate, acute, entire, ciliate, shortly petiolate, minutely pubescent, light green, indistinctly pinnatinerved like the leaves.

Stem erect, terete, herbaceous, pubescent, light green; 1st internode 2–4 mm. long.

First leaves ovate-oblong, acute or subobtuse, ciliate, sprinkled over with a few short hairs, light green, distinctly pinnatinerved.

Solanum Jacquinii, *Willd.*

Hypocotyl as in S. giganteum, but 3–4 cm. long.

Cotyledons lanceolate, acute, unequal, petiolate, minutely pubescent with distinct midrib and indistinct lateral nerves.

Stem as in S. giganteum; 1st internode 4–5 mm. long.

First leaves lanceolate-ovate, serrate, acute, pubescent, light green, distinctly pinnatinerved. Subsequently they become lyrate.

Solanum quitoense, *Lam.*

Primary root comparatively short, tapering downwards and branched.

Hypocotyl glandular-pubescent or hairy, 1·3–1·5 cm. long.

Cotyledons broadly ovate, acute or subacute, glandular-hairy on both surfaces, with a distinct midrib; lamina 1–1·2 cm. long, 6–8 mm. wide; petioles channelled above, 4 mm. long.

Stem with the primary internodes undeveloped.

Leaves radical as well as cauline, densely glandular-hairy, incurvinerved; petiole rather deeply channelled above.

No. 1. Broadly ovate, obtuse, entire.

No. 2. Cordate-ovate, obsoletely angled at the sides.

Capsicum sp. (fig. 545).

Hypocotyl erect, terete, thinly pubescent or nearly glabrous, pale green, 2–2·5 cm. above the soil.

Cotyledons oblong-lanceolate, acute, tapering considerably to both ends, foliaceous, subfleshy, with a few alternate ascending nerves, hardly discernible except on the under side, glabrous or very thinly pubescent, deep shining green above, pale beneath, 6–8·4 cm. long including the petiole, 5–7·5 mm. at the widest part; petioles long, semiterete, slightly channelled above, pale green, thinly glandular-pubescent.

Stem erect, terete, striate, thinly pubescent with upcurved hairs, pale or light green; 1st internode 2–2·4 cm. long; 2nd 1·4–1·8 cm.; 3rd 1·3–1·5 cm.

Leaves simple, cauline, alternate, exstipulate, petiolate, alternately, irregularly, ascendingly incurvinerved, faintly reticulate, thinly pubescent on the nerves or glabrous, thinly interspersed with sessile glands when very young, deep shining green above, paler beneath and shining, suddenly narrowed to a cuneate base, or even decurrent on the petiole; petiole semiterete, shallowly channelled on either side of a central obtuse ridge, slightly winged at the upper end, pale green, thinly glandular-pubescent.

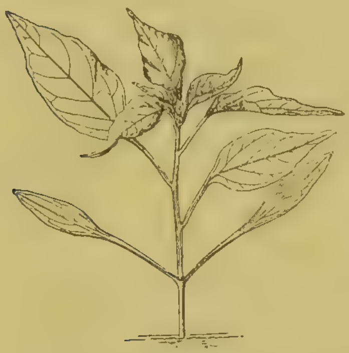

Fig. 545.—*Capsicum sp.* One-fourth nat. size.

No. 1. Narrowly ovate, acuminate, obtuse, minutely, erosely and irregularly dentate at the margin.

No. 2. Larger, similar or oblong-ovate, acuminate, obtuse, erosely dentate like the first.

Nos. 3–7. Lanceolate, acuminate, obtuse or subacute, often rather irregular in outline, pubescent at the margin, almost or quite entire.

Lycium afrum, *L.*

Hypocotyl erect, terete, glabrous, 2–3 cm. long, light green or colourless.

Cotyledons thick, fleshy, linear-oblong, obtuse, tapering to the base, entire, glabrous, one-nerved, with young buds in their axils.

Stem erect, terete, glabrous, herbaceous, ultimately woody, internodes from 7·5–10 mm. long.

First leaves simple, entire, alternate, fleshy, oval, obtuse, petiolate, glabrous, one-nerved like the cotyledons, exstipulate, but some of them have a small stipule-like leaf at the base.

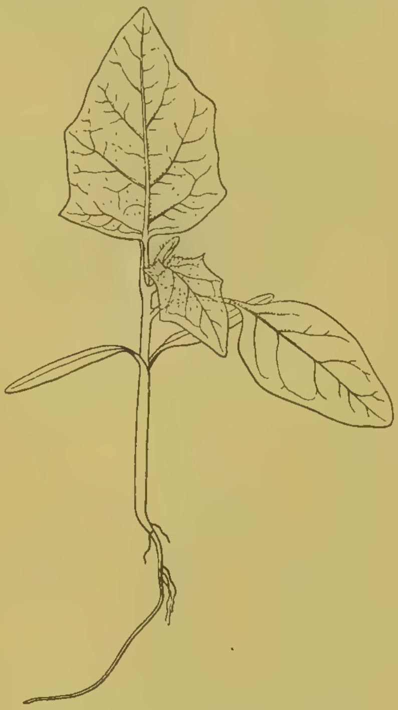

FIG. 546.—*Datura gigantea* Half nat. size.

Datura gigantea, *Hort.* (fig. 546).

Primary root long, tapering, colourless, giving off a few adventitious rootlets, annual.

Hypocotyl herbaceous, succulent, erect, terete, glabrous, purple, and shining, about 3 cm. long, 2·4 cm. thick, when the plant has developed two or three leaves.

Cotyledons linear, obtuse, petiolate, glabrous, succulent, one-nerved; lamina 2·5 cm. long, 4 mm. wide; petiole 7·5 mm. long.

Stem herbaceous, succulent, erect, terete, glandular when young, ultimately glabrescent, green, stained with purple; 1st internode 9 mm. long; 2nd 2 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, hairy on both surfaces when young, glabrescent when mature, alternately penninerved, deep green stained with purple, at least in the young state.

No. 1. Ovate-oblong, obtuse, entire, cuneate at the base.

No. 2. Triangular-ovate, subacute, subtruncate at the base, with two angles or blunt teeth on each side, foreshadowing lobing.

No. 3. Oblong, subacute, constricted near the base, trilobulate on each side.

Ultimate leaves large, triangular-cordate, subacuminate, obliquely pointed, lobulate and coarsely dentate, slightly unequal and trinerved at the base, with strong, branching, alternate nerves above, reticulate, pubescent on both surfaces; petiole terete with a shallow groove above the base on the upper side.

Cestrum Parqui, *L'Herit.* (fig. 547).

Primary root long, stout, with fine lateral rootlets.

Hypocotyl erect, terete, thinly pubescent, pale green.

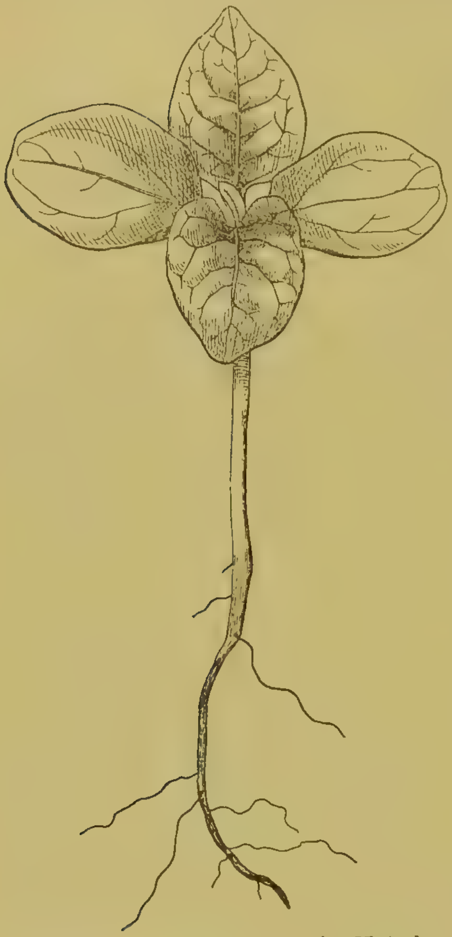

Fig. 547.—*Cestrum Parqui.* Nat size.

Cotyledons broadly oval, obtuse, with a broad shallow sinus at the apex, petiolate, obscurely, alternately incurvinerved and reticulate, with the midrib and two laterals proceeding from above the base much stronger than the rest, glabrous except on the midrib beneath, membranous, pale green; lamina 1·9–2·1 cm. long, and 1·5–1·6 cm. wide; petiole semiterete, flattened above, pubescent.

Stem erect, terete, pubescent; 1st internode 4·5 mm. long.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, glabrous except the midrib beneath and the petiole which are somewhat pubescent, alternately incurvinerved and reticulate; petiole semiterete, grooved above, short in the seedling stage.

Nos. 1 and 2. Cordate, cuspidate, obtuse, smaller than the cotyledons.

Cestrum elegans, *Schlecht.*

Hypocotyl erect, terete, glabrous, 8–10 mm. long, light green.

Cotyledons ovate-rotund, obtuse, entire, petiolate, glabrous, light green, without any apparent venation; petioles short, flat, shallowly furrowed on the upper side.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 5–7 mm. long; 2nd and 3rd shorter.

First leaves simple, entire, cauline, alternate, broadly lanceolate, almost acuminate, acute, hairy when young, afterwards clothed with a very minute bloom, petiolate, exstipulate, green, pinnatinerved; petioles short, furrowed on the upper side.

Schizanthus retusus, *Hook.* (fig. 548).

Primary root long, tapering, stout, colourless, with a few lateral fibres, annual.

Hypocotyl mostly subterranean, glabrous, terete, colourless in the lower half, purple above, 1·5 cm. long.

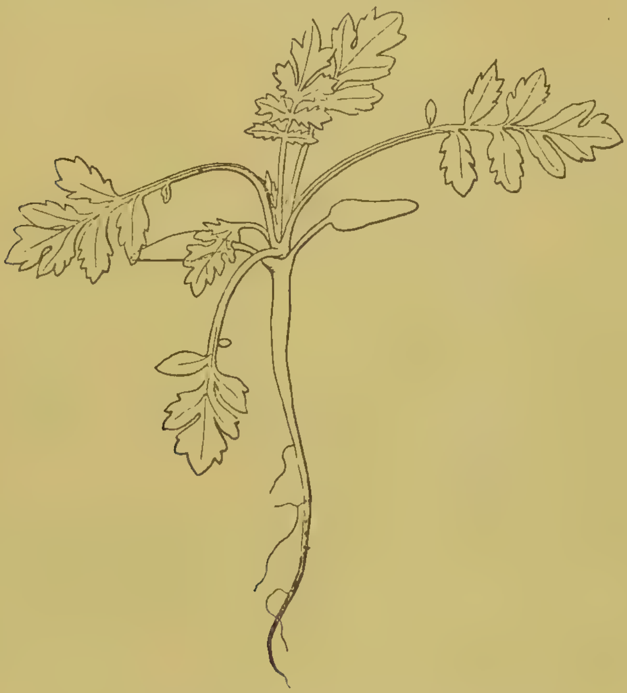

Fig. 548.—*Schizanthus retusus.* Nat. size.

Cotyledons foliaceous, bright green, glabrous, petiolate; lamina subulate-oblong, obtusely pointed, 1 cm. long, 3·5 mm. wide; petiole convex beneath, grooved above, 7 mm. long.

Stem annual and developed when about to flower.

Leaves pinnatisect, radical and cauline, opposite at least in seedling, exstipulate, petiolate, bright green, slightly pubescent when young, glabrescent; petioles channelled above, convex beneath, dilated at the base.

First pair slightly unequal, pinnatisect at the base, pinnatifid upwards, ovate in outline, obtuse; segments entire or slightly toothed.

Second pair ovate-oblong in outline, pinnatisect; lateral segments oblong, serrate; terminal lobe trifid with mostly entire segments.

Third pair similar but much more cut, with subpinnatifid segments.

Browallia elata, *L.* (fig. 549).

Primary root small, tapering downwards, with lateral fibres, annual.

Hypocotyl about 1 cm. long, ·5 mm. thick, terete, slender, pubescent.

Cotyledons nearly equal, petiolate, 5 mm. long including the petiole, 3·5 mm. wide, oblate, emarginate, obscurely nerved, slightly pubescent, pale green.

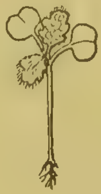

Fig. 549.—*Browallia elata.* Nat. size.

Stem very short, until it commences to grow for flowering.

Leaves simple, cauline, alternate, exstipulate, petiolate, alternately incurvinerved and reticulate, hairy all over, membranous, deep green above, paler beneath.

Nos. 1 and 2. About 4 mm. long, 3 mm. wide at first, ovate, deeply serrate, rounded at the base and apex, hairy all over, distinctly incurvinerved and reticulate, bright green, thin.

Brunfelsia sp. (fig. 550).

Hypocotyl woody, erect, terete, pubescent, soon becoming grey and throwing off the epidermis, about 1·8 cm. above the soil.

Cotyledons large, foliaceous, rotund-obovate, emarginate, coriaceous, petiolate, deep green above and thinly hairy, pubescent beneath, shining on both sides; laminæ variable in size from 1·5–1·9 cm. long, 1·5–1·8 cm. wide.

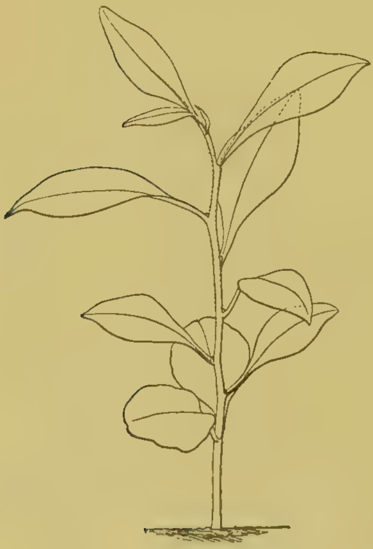

Fig. 550.—*Brunfelsia sp.* Half nat. size.

Stem woody, erect, terete, pubescent, pale green mottled with purple; 1st internode 8 mm. long; 2nd 6 mm.; 3rd 9 mm.; 4th 8 mm.; 5th 10 mm.; 6th 7 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, thinly glandular-pubescent on both sides, coriaceous, shining, deep or bright green above, paler beneath; petioles short, channelled above, convex on the back, densely glandular-pubescent, brownish.

Nos. 1–3. Elliptic, obtuse, tapering most to the base.

Nos. 4–8. Lanceolate-elliptic, obtuse, tapering more or less to both ends.

SCROPHULARINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 913.

Fruit and Seed.—The ovary is superior and two-celled, sometimes imperfectly, with large placentas adnate to the septa, or stalked and peltate or bipartite. The ovules are usually very numerous in each cell, rarely reduced to two, and cover the placentas in many series. They are anatropous or amphitropous, both types sometimes occurring even in one genus. The fruit is capsular, rarely baccate. During dehiscence the placentas are left in the centre where they form a column, or they are liberated from the septa, or at other times remain adnate to valves carrying two half-septa each. The seeds are usually very numerous with a basal or ventral hilum and sessile, or they have a short and slender or sometimes a dilated funicle hidden by the incurved margin. The testa is membranous or crustaceous and reticulate, foveolate, strongly ribbed or pitted, rarely smooth; in some cases it is hyaline and loose, while the endosperm is covered with a thin inner integument. Endosperm is generally copious and fleshy, rarely reduced to a thin layer or almost wanting. The embryo is comparatively large, and varies from half to nearly the whole length of the endosperm; rarely minute; it is generally straight but sometimes slightly curved, very rarely curved in the form of a ring. The cotyledons are shorter or longer, but not as a rule very much broader than the radicle which is superior or horizontal and directed towards the hilum.

Some cases occur in the Order—as in Melampyrum, Tozzia, Leptorhabdos, and a few species of Veronica—where the ovary has two ovules in each cell. The fruit is baccate in Teedia, Dermatocalyx, Halleria, and Leucocarpus, and the one-seeded capsule of Tozzia dehisces rather tardily. Endosperm is very scanty in Melosperma and a few others; and is altogether wanting in Monttea and Wightia.

The seeds are generally numerous and comparatively small; but sometimes large and much modified in form. One of the simplest types is that occurring in Scrophularia nodosa. The seed is oblong or oval, undulated or rugose on the surface. The embryo is nearly as long as the endosperm with narrowly oblong cotyledons, shorter than the radicle. The seed of Pedicularis gracilis is obovoid and reticulate with the reticulations considerably elevated so as to form deep areolæ. The embryo is three-fourths the length of the seed, and the cotyledons are roundly oval, about equalling the radicle in length. The seeds of Collinsia violacea are broadly oval and flattened or slightly concave on the ventral face on which the hilum is situated.

The seeds of Paulownia imperialis are small, oblong, very numerous, and girt by a broad hyaline lacerated wing resembling a number of distinct appendages.

At least three very distinct types are met with in the genus Linaria. The seeds of L. vulgaris (fig. 552) are pendulous, anatropous, much flattened with the testa produced into a wing all round the margin except at the hilum where they are notched. The embryo is as long as the endosperm, and lies in the broader plane of the seed. The cotyledons are oval-oblong, shorter but much wider than the radicle, with their backs to the placental axis, but nearly always more or less oblique to it as if they had become twisted into this position owing to the flattening of the seed.

The ovules of L. genistifolia are horizontal and anatropous, while the mature seeds are oblong-obovoid and variously angled by being densely packed; they are always broadest at the end abutting on the pericarp. The embryo is straight and nearly equals the endosperm in length, and the oval plano-convex cotyledons have their longitudinal axis at right angles to the placental axis. The latter character, however, varies somewhat according to the position of the seed on the placenta. In general characters, L. Cymbalaria (fig. 554) agrees with L. genistifolia, but the seeds are globoso-ovoid, and the crustaceous testa is deeply ridged and furrowed longitudinally. The embryo is little more than half the length of the endosperm and has very short cotyledons. In L. reticulata the seed is slightly curved and transversely ridged. The embryo is also slightly curved in conformity with the seed.

A third type is represented by L. purpurea and L. repens. The seeds are peltate and transverse to the placenta, oval in outline, somewhat compressed dorsally, and variously angled by mutual pressure. The testa is thick, crustaceous, variously ridged, furrowed, and reticulate. The embryo is straight, nearly equalling the endosperm in length, while the oval cotyledons are much shorter than the terete radicle.

A somewhat similar variation of the seeds is met with in the genus Veronica. Four different types have come under my notice. The simplest is that met with in V. serpyllifolia (fig. 567). The seeds are anatropous, but the radicle may be superior, horizontal or inferior according to the position of the seed on the elevated cushion-like placenta. The seeds are also very minute and much flattened, but in transverse section oval or oblong according to their stage of maturity and other causes. The embryo varies from one-half to three-fourths the length of the endosperm, and the short cotyledons are scarcely wider than the radicle.

The ovules of V. arvensis are amphitropous and the seeds (fig. 562) peltate, dorsally flattened, variable in outline owing to mutual pressure and overlapping one another. The ventral face is somewhat concave with a central elevation on which the hilum is situated. The embryo is more than half the length of the endosperm, with ovate cotyledons much shorter than the radicle. V. salicifolia agrees pretty closely with V. arvensis notwithstanding the fact that the former is an erect shrub, while the latter is a procumbent annual herb. The seeds are however slightly less elevated on the ventral face, and the embryo is considerably shorter.

The ovules of Veronica Buxbaumii are pendulous, horizontal or ascending, and semianatropous, and the hilum varies accordingly. The seeds (fig. 563) vary from eight to twelve in each cell, and are oblong, rounded at either end, deeply concave on one face and deeply ridged and furrowed on the dorsal or convex aspect. The short funicle is partly hidden at one end of the groove. The embryo is very similar to that of V. salicifolia, but relatively to the seed is very much shorter.

A fourth type occurs in V. hederæfolia (fig. 564) which bears only two ovules in each cavity of the ovary. The seed is large compared with any of the above, V. Buxbaumii excepted: it is deeply concave on the ventral face by the inrolling of the edges and the stout funicle arising from the centre of the cavity is almost or quite concealed. The seed both in longitudinal and transverse section greatly resembles that of a species of Galium. The embryo is much larger than that of V. Buxbaumii, situated at the upper end of the seed, and slightly curved in conformity with it.

In Melampyrum the seeds closely resemble, in form, size and colour, the pupæ of Ants; and I have observed that, whether by mistake or design, they are sometimes carried off by Ants into their nests. It is possible therefore that the similarity may be of use, as assisting in their dispersion.

Seedlings.—The cotyledons in this Order are generally moderate in size, and sometimes even small. The largest observed are some of the annual species of Veronica, the seeds of which are large and few in a capsule. They also become greatly elongated in many species of Linaria by intercalary growth after germination. They are always of simple types, and about half a dozen rather distinct kinds were observed.

The cotyledons of Veronica salicifolia are ovate or almost lanceolate and very small. The first two pairs of leaves are small, lanceolate and entire. Succeeding ones are more or less serrate and gradually increase in size, but retain the same shape. The ultimate ones are oblong-lanceolate, serrate and trinerved. The cotyledons of an unnamed species of Scrophularia are lanceolate and rather elongated. The first pair of leaves are broadly ovate and entire.

Scrophularia chrysantha may serve as a type with broadly ovate and entire cotyledons. The first pair of leaves are elliptic, and entire. The cotyledons of Rhodochiton volubile (fig. 556) are very similar. The first two pairs of leaves are cordate and serrate, succeeded by three pairs which are larger, more acuminate, and very unequally serrate. An unnamed species of Pedicularis differs in having smaller and more obtuse cotyledons. The first pair of leaves are ovate-oblong, shallowly pinnatifid with rounded serrulate lobes.

The cotyledons of Calceolaria chelidonioides (fig. 551) are very small, suborbicular and entire. The first two pairs of leaves are broadly ovate and serrate; the third pair are triangular and pinnatifid. Linaria Cymbalaria (fig. 555) differs very much from all other species of the genus noticed. The cotyledons are small, rotund, entire, mucronate, and unequal in size. The hypocotyl remains very short and does not develop adventitious buds as in most other species. Branches are, however, given off from the axils of the cotyledons, and the stems are procumbent. The first pair of leaves are cordate-reniform and shallowly crenate; but the second pair are rather more acutely toothed.

A large proportion of seedlings have suborbicular and emarginate cotyledons. Those of Collinsia bicolor (fig. 559) are shallowly tridentate, and three- to five-nerved, but the venation is descernible only when the cotyledons begin to decay or dry up. The first three pairs of leaves are ovate, serrate, and subcordate at the base. C. parviflora and C. multicolor agree pretty closely with C. bicolor, except that the cotyledons are rather more decidedly emarginate. The first pair of leaves of C. parviflora are incipiently trifid; those of C. multicolor are crenate and emarginate. The cotyledons of Paulownia imperialis (fig. 558) conform to this type, but are very small. The first pair of leaves are roundly ovate and distantly dentate, succeeded by three pairs that are successively much larger, more decidedly cordate, and more deeply dentate. Alonsoa incisæfolia has the cotyledons and hypocotyl pilose, and the first pair of leaves are incise-serrate and relatively broader than in the adult. Veronica Waldsteiniana is notable for its dwarfed hypocotyl and the breadth of the first pair of leaves. An unnamed species of Veronica closely allied to V. hederæfolia is notable in the Order for the size of its cotyledons which are orbicular, trinerved throughout their length, with the lateral nerves uniting with the midrib at its apex. They are also conspicuously emarginate with a tooth in the notch. The first pair of leaves are suborbicular and deeply incised with rounded teeth. V. hederæfolia (fig. 566) has also exceptionally large cotyledons, but they differ somewhat from any of the above in being oblong-oval and only slightly, if at all, emarginate. The large, concave seed and the mode of germination are shown in fig. 565. Pentstemon Mackayanus has entire or slightly emarginate cotyledons, and the first pair of leaves are broadly ovate and entire. Another slight departure from the type is met with in an unnamed species of Calceolaria, where the cotyledons are somewhat broader than long, and the two first leaves are broadly ovate and rather acutely serrate.

The seedling of Scrophularia sambucifolia (fig. 557) closely resembles that of some species of Salvia. The cotyledons are roundly triangular and obtuse. The two first pairs of leaves are cordate and crenate. The ultimate leaves are interruptedly pinnatisect and lyrate; the lower segments are small and roundly cordate and crenate, while the terminal one is very large and oblong-cordate; minute intermediate segments often occur between the larger ones. The cotyledons of Torenia Fournieri (fig. 561) are emarginate and slightly cordate at the base, but otherwise shaped like those of the last species. As they get very old they appear to lose the basal sinus and to become more reniform. The leaves are all ovate and serrate.

One of the most remarkable types is that in which the cotyledons greatly enlarge by intercalary growth, and alter their shape after germination, as happens in Streptocarpus, and in several genera belonging to the Onagrarieæ already mentioned. I have noted it in Mimulus luteus (fig. 560) and in Linaria. The cotyledons of the former are triangular and incipiently trifid when full grown. The terminal tooth represents the original and true lamina of the cotyledons soon after germination. The seedling itself is dimorphic according to circumstances. If it has plenty of room to develop in the seed-bed the primary leaves are triangular, while the internodes of the stem are hardly developed; but if the seedlings are crowded, the primary internodes elongate considerably and the leaves become oval.

The cotyledons of Linaria become greatly elongated and are incipiently trifid. Those of L. tristis are cuneate-linear. The cotyledons of L. genistifolia are lanceolate or ovate-lanceolate and slightly constricted about the middle. The cotyledons of L. striata are elliptic and 3·5–4·25 mm. wide in the middle; and the primary leaves are in pairs. Those of L. bipartita (fig. 553) are linear and entire. The first five pairs of leaves are lanceolate and trinerved at the base.

A remarkable peculiarity of all the species of Linaria noticed except L. Cymbalaria is that the hypocotyl develops a group of adventitious buds from a point near the surface of the ground. The primary stem after producing a few pairs of leaves ceases to elongate. The adventitious buds or a number of them grow strongly and soon overtop the primary axis which they supersede, and constitute the flowering stems. Both annuals and perennials, with the exception above mentioned, behave in this way. The cotyledons often bear a close resemblance to the leaves of the primary axis. The tip above the constriction constitutes the original and true lamina of the cotyledon; all below it is developed as a result of intercalary growth subsequent to germination.

Calceolaria chelidonioides, *H. B. K.* (fig. 551).

Primary root short, tapering, succulent and soft, with a few lateral fibres, annual.

Hypocotyl succulent, glandular-pubescent, merging into the root.

Cotyledons small, soon withering, pale green, petiolate; petiole 1·5 mm. long; lamina small, rotund, 2 mm. in diameter.

Stem erect, soft, succulent, green or purplish by exposure, sparsely glandular-pubescent; 1st internode 2 cm. long; 2nd 3 mm.; 3rd 5 mm.

Leaves simple, cauline, opposite, exstipulate, petiolate, glandular-pubescent or hairy, deep green above, paler beneath; petioles convex, and glabrous on the under side, channelled above and glandular-hairy.

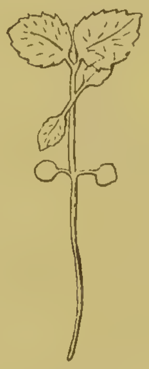

FIG. 551.
Calceolaria chelidonioides.
Nat. size.

First pair very small, ovate, subacute, serrulate.

Second pair ovate, subacute, serrate, much larger than the first pair.

Third pair triangular, subacute, pinnatifid at the base with the lobes oblong, obtuse, and like the upper part of the leaf simply or doubly serrate.

Alonsoa incisæfolia, *Ruiz et Pav.*

Hypocotyl erect, terete, pubescent or hairy, 1·5–2·5 cm. long, light green or colourless.

Cotyledons membranous, ovate-rotund, obtuse, emarginate (though very young ones seem almost entire), petiolate, covered with rather long glandular hairs, light green, one-nerved.

Stem erect, terete, herbaceous; 1st internode 3–5 mm. long.

First leaves simple, deeply and obtusely serrate, cauline, opposite, acute, petiolate, exstipulate, covered with hairs, light green, pinnatinerved.

Linaria purpurea, *Mill.*

Ovary two-celled, with about ten ovules in each cell; ovules peltate, amphitropous; micropyle at one end of the horizontal ovule.

Capsule obovoid, emarginate, postero-anteriorly furrowed at the junction of the carpels, two-celled, with six to eight seeds in each cell, dehiscing at the apex by two openings each with three teeth or valves, 3–3·5 mm. long, 3·5–4·25 mm. wide, 2·5–3 mm. thick.

Seeds peltate, or transverse to the receptacle, broader right and left of the attachment than above and below, somewhat compressed dorsally, variously angled by mutual pressure, reticulate and variously ridged and furrowed; testa thick, crustaceous, black when mature; hilum inconspicuous, ventral; micropyle transverse and either right or left of the axis.

Seed 1–1·25 mm. wide, ·5–·6 mm. long and thick.

Endosperm copious, fleshy, white.

Embryo straight, colourless, nearly equal in length to the endosperm, transverse to the placenta; cotyledons oval, obtuse, entire, sessile, plano-convex, vertical to the axis with their backs to it; radicle terete, obtuse, horizontal, and pointing right or left of the placental axis.

Linaria repens, *Steud.*, conforms to this type.

Linaria vulgaris, *Mill.* (fig. 552).

Ovary two-celled, ovules many, seated all over a peltate enlarged placenta, pendulous, anatropous or semianatropous, radicle superior.

Capsule short, oblong, dehiscing at the apex by four to six valves, two-celled, many-seeded (seeds about one hundred and twelve). When fresh 8–10 mm. long and 5–7 mm. in diameter.

Seed orbicular, much imbricated, winged with a basal notch, sessile on a little projection of the placenta, flattened on the ventral aspect or slightly concave by the recurving of the marginal wing, convex and compressed laterally, with the central part containing the endosperm and embryo the thickest. Testa furnished with scattered minute raised points, finely and minutely reticulate especially towards the margin of the disc, the wing substriate, pale green when young, becoming white, ultimately black; hilum inconspicuous, superior and close to the micropyle, in or close to the basal notch of the wing of the seed, 1·75–2·25 mm. in diameter.

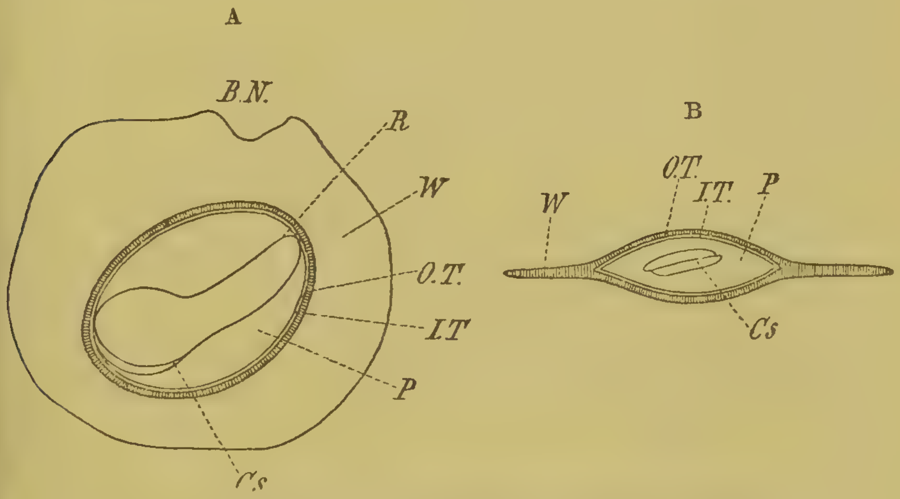

FIG. 552.—*Linaria vulgaris*, × 20. A, longitudinal section of seed. B, transverse section of seed: *BN*, basal notch; *W*, wing; *OT*, testa; *IT*, tegmen; *R*, radicle; *Cs*, cotyledons; *P*, endosperm.

Endosperm copious, colourless, occupying the central disc of the seed, which is more or less oval, and lies obliquely to the hilum or basal notch.

Embryo curved, in most cases nearly equalling the diameter of the endosperm, colourless; cotyledons oval-oblong, obtuse, entire, plano-convex or nearly flat, closely adpressed face to face, and most often obliquely to one another, sessile, lying in the broader way of the seed with their backs to the axis; radicle terete, obtuse, superior, and close to the micropyle, much thinner than the width of the cotyledons and nearly twice as long.

The two following Species agree with this Type.

L. saxatilis, *DC.*

Capsule 3–4 mm. long, 3·4 mm. wide, and 2·75–3·25 mm. thick when fresh.

Seeds twenty to twenty-eight in a capsule about 1·5–1·75 mm. in diameter, much more decidedly echinulate all over the disc than those of L. vulgaris.

L. alpina, *DC.*

Capsule opening by six valves, three- to six-seeded, twelve- to twenty-ovuled, 3·25–3·5 mm. long, 2·5–3 mm. wide, and 2–2·25 mm. thick.

Seeds orbicular, concave on the ventral aspect, 2–2·25 mm. in diameter.

Linaria genistifolia, *Mill.*

Ovary two-celled, many-ovuled; ovules horizontal, anatropous, seated on an elevated or enlarged placenta; micropyle horizontal and abutting against the placental axis.

Fruit a capsule, broadly ovoid, obtuse, glabrous, subglaucous-green, two-celled, many-seeded, dehiscing at the apex by four valves.

Capsule 5·5–6 mm. long, 5–5·5 mm. wide, 4·5–5 mm. thick, containing one hundred and twenty to one hundred and thirty-six seeds.

Seeds oblong-obovoid, variously shaped and angled by mutual pressure, reticulate, densely packed horizontally all over the axis, broadest at the end abutting on the pericarp; testa thick, crustaceous; hilum basal, inconspicuous; micropyle contiguous to the hilum.

Seed 1–1·25 mm. long, about ·75 mm. wide, and ·5 mm. thick.

Endosperm comparatively copious, but occupying only a small portion of the seed, fleshy, white.

Embryo straight, nearly equal in length to the endosperm, colourless, small; cotyledons oval, obtuse, entire, sessile, plano-convex, with their long axis at right angles or perpendicular to the placental axis; radicle terete, obtuse, considerably longer than the cotyledons, close to the hilum and pointing to the placenta.

Seedling.

Primary root tapering downwards, fibrous, perennial.

Hypocotyl terete, slender, glabrous, green or glaucous-green, 1–2 cm. or more above the soil, ultimately decumbent, sometimes proliferous immediately above the soil, and giving off one to six or more branches that soon become stronger and longer than the primary stem or plumule. This it is able to do even if the cotyledons and plumule should be broken off.

Cotyledons lanceolate or ovate-lanceolate, obtuse, narrowed into a short petiole, slightly constricted about the middle of the lamina, glabrous, glaucous on both surfaces; lamina 4–6·75 mm. long, 2·25–4 mm. wide; petiole slightly channelled above, convex beneath, ·5–1·75 mm. long.

Stem herbaceous, erect, terete, glabrous, glaucous-green; 1st internode 4–7·5 mm. long; 2nd shorter. First internode of branches from the hypocotyl 1–1·5 cm. long.

Leaves simple, entire, cauline, with the lower and primary ones opposite or in whorls of three to four, shortly petiolate, deeply glaucous on both surfaces, glabrous, trinerved at the base with a few alternate, ascending nerves upward, rather opaque, and best observed by transmitted light; petioles very short, tapering downwards, slightly channelled above, convex beneath.

First and second pairs lanceolate-elliptic, obtusely pointed.

First node on the branches bearing two, or on strong branches three elliptic or lanceolate-elliptic obtusely pointed leaves.

Linaria reticulata, *Desf.*

This species agrees with L. genistifolia in the horizontal anatropous ovules and seeds, but differs in the latter being slightly curved and transversely ribbed, not angled. The embryo is also similar, but slightly curved in conformity with the seed.

Capsules 3·5–4 mm. long, 3–3·25 mm. wide, 2·75–3·25 mm. thick, containing one hundred and thirty-three to one hundred and thirty-six seeds.

Seeds ·75 mm. long, ·25–·5 mm. wide, but variable and thickest at the end farther from the hilum.

Linaria striata, *DC.*

Hypocotyl as in L. genistifolia; 1·2–2·7 cm. above the soil, becoming early proliferous at the surface, and bearing three to five or more branches soon exceeding it in length and strength.

Cotyledons elliptic, obtuse, glabrous, glaucous-green and rather opaque above, paler beneath, with the midrib only discernible; lamina 7 mm. long, 3·5–4·25 mm. wide in the middle; petiole channelled above, convex beneath, glabrous, 1·5–3 mm. long.

Stem.—1st internode 1–1·3 cm. long; 2nd 1·65 cm.; 3rd 1–1·2 cm.

Leaves as in L. genistifolia.

First pair elliptic, obtuse.

Second pair narrower, lanceolate-elliptic or oblong-elliptic, obtuse.

First, second and third whorls on the branches similar to those on the primary stem, and wide or narrow according to the strength of the seedling.

Linaria bipartita, *Willd.* (fig. 553).

Primary root tapering downwards and giving off fibrous lateral rootlets.

Hypocotyl long, erect, slender, becoming thickened upwards, thinly glandular-pubescent, 2–3·5 cm. long, shining, green or more or less stained with red, proliferous at the surface of the soil, giving off buds that eventually grow stronger than the primary stem, and elongate from 2–6 cm. before producing any leaves, appearing thus as a continuation of the hypocotyl. If the upper part of the hypocotyl and cotyledons are removed after germination, the seedling has still power to grow and establish itself by means of this proliferation.

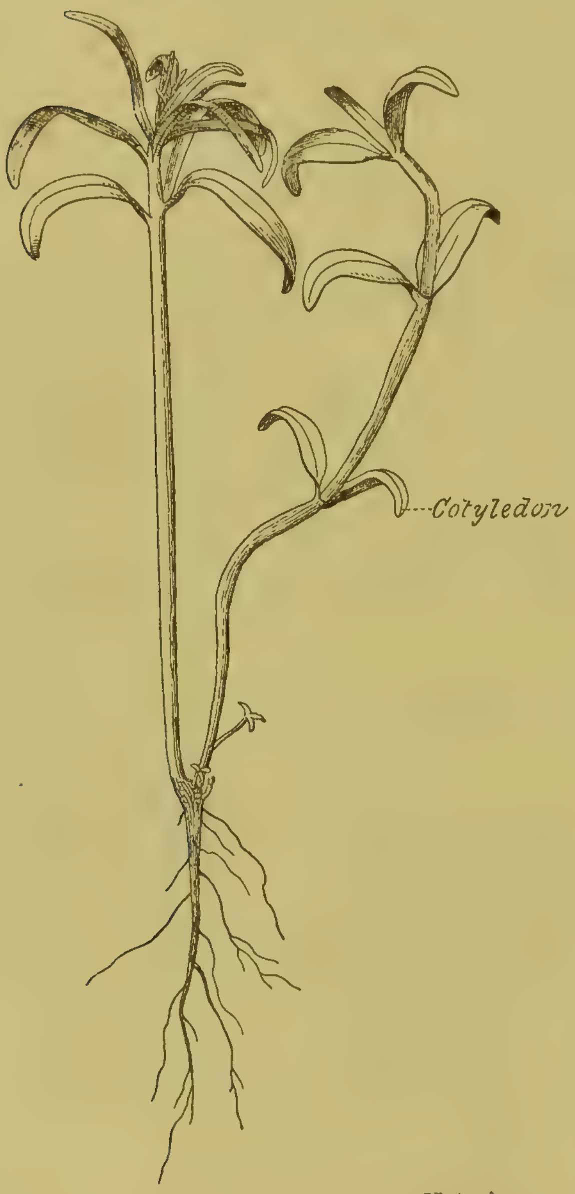

Fig. 553.—*Linaria bipartita.* Nat. size.

Cotyledons linear, obtuse, entire, tapered at the base to a short petiole, glabrous, bright green above, paler or subglaucous beneath, often recurved or more or less revolute at the tip, 1·1–1·3 cm. long including the very short petiole, 2·25–2·75 mm. wide, rather fleshy, distinctly one-nerved.

Stem herbaceous, erect, terete, thinly glandular-pubescent, green or more or less stained with red at the base; 1st internode 2–2·6 cm. long; 2nd about 1·6 cm.; 3rd shorter.

Leaves simple, entire, cauline, the lower opposite, or verticillate in whorls of three or more, the upper alternate, exstipulate, very shortly petiolate or subsessile, glabrous, light or dark shining green above, subglaucous beneath, rather fleshy, trinerved at the base, with a few alternate ascending nerves upwards.

First to fifth pairs lanceolate, obtuse, trinerved at the base with a few indistinct alternate ascending nerves upwards, very shortly petiolate.

Leaves on the stems from the proliferous hypocotyl much narrower than those on the primary stem, linear and opposite, or in whorls of three, gradually tapered to the base.

Linaria Cymbalaria, *Mill.* (fig. 554).

Capsule 4·5–6 mm. long, 4–5·5 mm. wide, and 3–4·5 mm. thick, containing forty-two to eighty seeds.

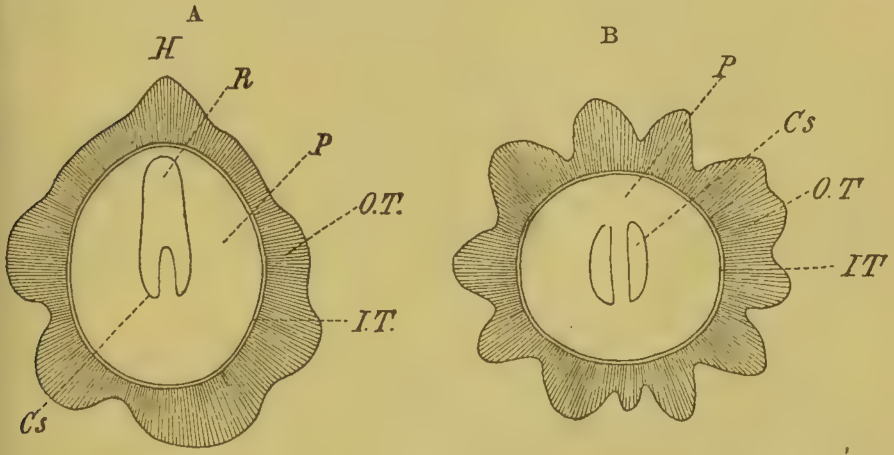

FIG. 554.—*Linaria Cymbalaria*, × 40. A, longitudinal section of seed. B, transverse section of seed: *R*, radicle; *P*, endosperm; *OT*, testa; *IT*, tegmen; *Cs*, cotyledons; *H*, hilum.

Seeds oval or globose-oval, deeply ridged and furrowed longitudinally with a very thick testa, 1 mm. long, ·75 mm. in diameter.

Embryo.—The cotyledons with their edges vertical to the axis, but varying apparently according to the position of the seed in the capsule.

Seedling (fig. 555).

Primary root slender, flexuose, with very fine lateral rootlets.

Hypocotyl decumbent, subflexuose, thinly pubescent, tapering indistinguishably into the root, not giving rise to adventitious buds.

Cotyledons rather unequal, thinly pubescent, pale green, rotund or subreniform, mucronate, entire, 4·5 mm. long, 5 mm. wide; petiole thinly pubescent, channelled above, about 7–9 mm. long.

Stem herbaceous, trailing, terete, thinly pubescent, green or purplish, brittle, succulent; 1st internode 6 mm. long.

Leaves alternate (first four to six in opposite pairs, but developing unequally from the bud), thinly pubescent in seedling stage but glabrous or almost so in the adult plant, green or stained with purple on the under side, and especially the petioles; petioles slightly channelled on the upper side, subterete, thinly pubescent in the seedling stage, glabrous or almost so in the adult stage, green or purplish.

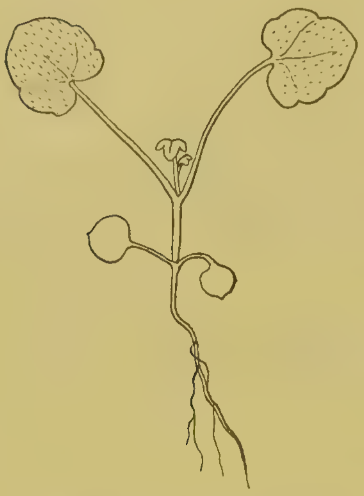

FIG. 555.—*Linaria Cymbalaria.* Nat. size.

First pair cordate-reniform, mucronate, shallowly three- to five-crenate, obscurely trinerved.

Second pair cordate, rather acutely five- to seven-toothed, obscurely five-nerved.

Ultimate leaves alternate on the trailing stems and branches, reniform, five- to seven-nerved, with five to seven large, rounded, mucronate crenatures on the lower and larger leaves, and five to seven triangular or ovate, deep, acute teeth on the smaller and upper leaves.

Linaria tristis, *Mill.*

Hypocotyl colourless, becoming proliferous at the surface of the ground, and throwing out from one to many buds which develop into branches with verticillate leaves, three to four in the first whorl, 1·5–2 cm. long.

Cotyledons cuneate-linear, narrowed gradually to the base, constricted above the middle or towards the apex, and appearing tridentate there with the lateral teeth rudimentary and the terminal subulate, obtuse or subacute, opaque, deep subglaucous-green and convex above, paler beneath and concave, 9–12 mm. long, 2·5–3 mm. wide immediately beneath the constriction where they are widest.

Stem herbaceous, erect, terete, glabrous, pale green; 1st internode 3–9 mm. long; 2nd shorter.

Leaves verticillate, narrowed to the base but scarcely petiolate, glabrous, deep opaque green or glaucous above, paler beneath.

First whorl of four leaves linear, obtuse, flat or subrevolute at the margins, glaucous in the seedling.

Second whorl very frequently consisting of five leaves similar to the first. The whorl sometimes consists of four leaves. Occasionally a leaf of the first whorl is carried up on the internode above it, and occasionally a leaf of the second whorl may be below the level of the others.

Above this the most frequent number of leaves in a whorl seems to be four; but it varies from three to five, and occasionally the whorls are broken or interrupted.

Ultimate leaves four to five in a whorl, lanceolate-linear, subacute, deep opaque or glaucous-green, with a shallow channel above, paler beneath with a prominent midrib and two faint lateral nerves near to and parallel with the margin, and indistinct, alternate, ascending nerves passing from the midrib to the submarginal nerves.

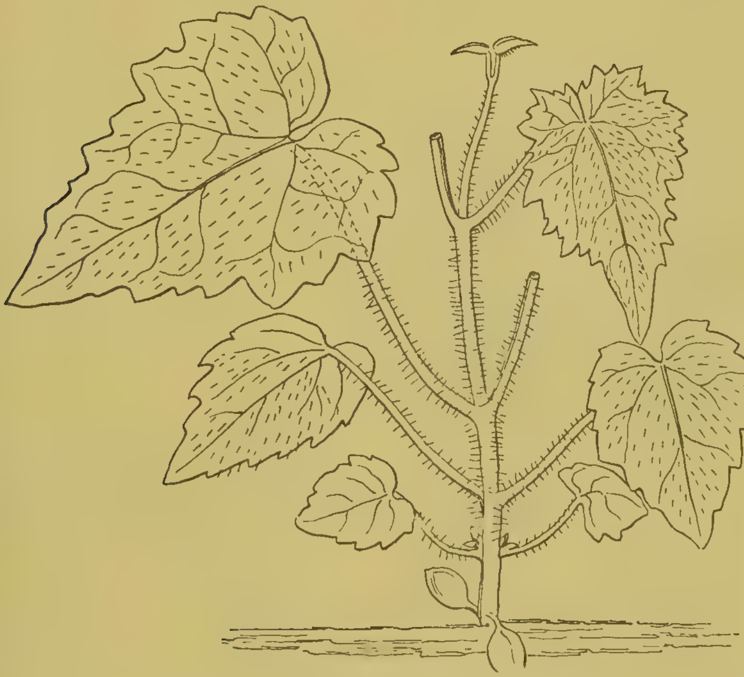

Fig. 556.—*Rhodochiton volubile.* Nat. size.

Rhodochiton volubile, *Zucc.* (fig. 556).

Hypocotyl subterranean or short.

Cotyledons petiolate, coarsely and thinly hairy; lamina rotund-ovate, apiculate, 6 mm. long, 5 mm. wide; petiole channelled above, tapering downwards, 3 mm. long.

Stem erect, terete, thick and succulent at the base, and becoming much more slender upwards as it commences to twine, villous, purplish; 1st internode 7 mm. long; 2nd 5·5 mm.; 3rd 9·5 mm.; 4th 9·5–10 mm.; 5th 1·6 cm.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate, coarsely hairy on both sides with stiff hyaline hairs; petioles channelled above, and hairy like the leaves and stem, purplish.

First pair small, cordate, acute, crenate-dentate with mucronate teeth; lamina 1·3 cm. long, 1·1 cm. wide.

Second pair cordate, acute, serrate-dentate with mucronate teeth, faintly five-nerved.

Third pair cordate, acuminate, serrate-dentate, acute or sublobulate below the middle, strongly nerved with five ascending and incurved nerves, and subreticulate.

Fourth pair cordate, acuminate, acute, acutely dentate-serrate, sublobulate on the lower half, nerved like the third pair.

Scrophularia sambucifolia, *L.* (fig. 557).

Primary root soon ceasing to elongate, and giving off almost horizontal secondary ones near its base.

Hypocotyl erect, terete, slender, pubescent, pale purplish, 1–1·3 cm. long, ·75 mm. thick.

Cotyledons roundish-triangular, obtuse, glabrous, convex above; lamina 5·5 mm. long, 6 mm. wide; petiole channelled above, convex below, pubescent, 6 mm. long.

Stem slender, erect, terete, hairy, pubescent, herbaceous; 1st internode 2·5 mm. long; 2nd 1 mm.

Leaves cauline, simple, opposite, decussate, exstipulate, petiolate, glandular-pubescent or hairy on both surfaces as well as on the petioles.

First pair rotund-cordate, obtuse, shallowly crenate.

Second pair rotund-cordate, more deeply crenate than the first pair.

Ultimate leaves lyrate, interruptedly pinnatisect, crenate with mucronate serratures, glandular-pubescent above and on the nerves beneath, and dotted with sessile glands, alternately penninerved, reticulate, rugose; terminal segment cordate-oblong, obtuse; lateral segments alternate, more or less imbricate, rotund-cordate, obtuse, unequal at the base, more or less cut away on the anterior basal side, decurrent on the petiole with a narrow wing, and irregularly interspersed with minute segments; larger segments three to five.

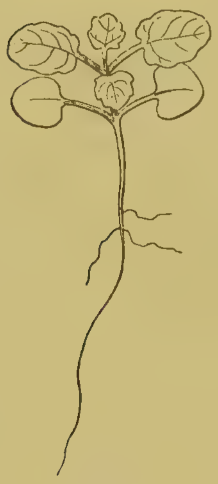

FIG. 557. *Scrophularia sambucifolia.* Nat. size.

Scrophularia chrysantha, *Jaub. et Sp.*

Hypocotyl covered with numerous glandular hairs, light green or almost colourless, 5–8 mm. long.

Cotyledons rotund-ovate, about 5 mm. long including the petiole.

Stem with primary internodes but slightly developed.

First leaves elliptic, subacute, entire, shortly petiolate, covered with glandular hairs and ciliated.

Paulownia imperialis,[1] *Sieb. et Zucc.* (fig. 558).

Hypocotyl erect, terete, very short, glandular-pubescent, about 5 mm. long.

Cotyledons transversely oval or rotund, petiolate, shallowly emarginate, showing a midrib only, thinly glandular-pubescent or glabrous, light green above, paler beneath; lamina about 4·5 mm. long, 5·5 mm. wide; petiole flattened above or slightly grooved, 3–4 mm. long.

Stem erect, terete, densely glandular-pubescent or shaggy, and almost villous in a young state, ultimately woody, forming a tree; 1st internode 5·5 mm. long; 2nd 1·15 cm.; 3rd 1 cm.

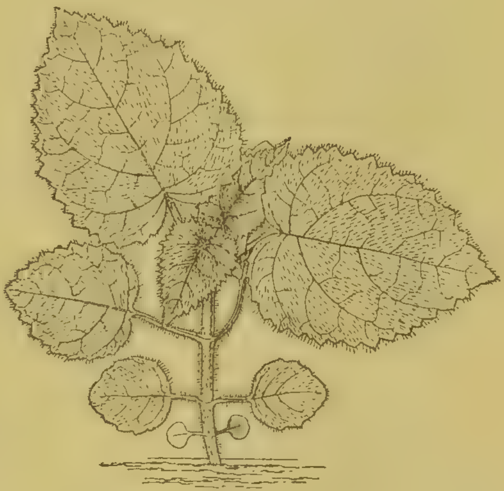

FIG. 558.—*Paulownia imperialis.* Half nat. size.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately ascendingly incurvinerved, with the nerves uniting at their upper end and giving off branches into the marginal teeth, reticulate, softly and densely glandular-hairy on both surfaces, deep green above, paler beneath; petioles subterete, narrowly channelled above, densely glandular-hairy and shaggy, tapering upwards from a stout base.

First pair small, broadly ovate or rotund-ovate, obtuse, distantly glandular-dentate.

Second pair cordate, obtuse, irregularly glandular-dentate.

Third pair much larger, cordate, subacute, dentate, with unequal-sized teeth generally largest about the middle of the leaf, and tipped with a glandular mucro.

Leaves on vigorous young trees attain a length of twelve to twenty-four inches exclusive of the petiole.

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[1] The seed is figured by Tubeuf, *Samen, Früchte und Keimlinge*, p. 74.

Pentstemon Mackayanus, *Knowl. et Westc.*

Hypocotyl erect, terete, minutely pubescent, 4–6 mm. long, light green or colourless.

Cotyledons ovate-rotund, obtuse, entire or sometimes minutely emarginate, petiolate, glabrous, dark green, with no apparent venation.

Stem erect, terete, herbaceous, finely pubescent, light green; 1st internode 3–5 mm. long; 2nd much shorter.

First leaves simple, cauline, opposite, decussate, ovate, obtuse, petiolate, exstipulate, with a few scattered hairs, trinerved with indistinct upper lateral veinlets; the first pair are entire; the second crenate.

Collinsia bicolor, *Benth.* (fig. 559).

Primary root long, tapering, with fibrous lateral rootlets, annual.

Hypocotyl erect, terete, minutely pubescent, green or reddish-purple, 1·3–1·5 cm. long.

Cotyledons rotund, or rotund-ovate, rounded at the base, minutely emarginate at the apex, fleshy, glabrous except the petioles, dull light green or stained with red and dotted with white; lamina 5–10 mm. long, and as wide, or slightly longer than wide; petioles semiterete, channelled above, minutely pubescent, dilated towards the base and connate, 6·5–9·5 mm. long. Lamina obscurely and alternately incurvinerved, and reticulate, venation seen only when the cotyledon is decaying.

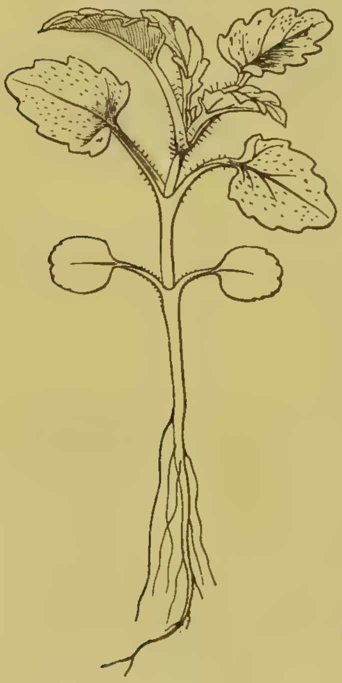

Fig. 559.—*Collinsia bicolor.* Nat. size.

Stem herbaceous, annual, erect, terete, minutely pubescent with deflexed hairs, or subglabrous, pale green or stained red; 1st internode 7–13 mm. long; 2nd 4–13 mm. according to strength of plant.

Leaves simple, cauline, opposite, exstipulate, petiolate, thinly hairy above, subglabrous beneath, alternately and ascendingly penninerved, deep opaque green above and dotted with white, much paler, almost glaucous beneath and shining; petioles semiterete, channelled above, hairy, dilated towards the base and subconnate.

First pair ovate, obtuse, subcordate at the base, crenate-serrate. This is the most common type, but seedlings occur frequently with the first pair of leaves deeply trilobed; lateral lobes unequally oblong or unequally obovate with a few teeth on the posterior side; terminal lobe oblong-cuneate or rhomboid-cuneate, crenate or obtusely dentate.

Second pair ovate, obtuse, shallowly cordate at the base, obtusely serrate. This is the usual type, but more rarely the second pair become lobed like the first.

Third and fourth pairs oblong-ovate, obtuse, rounded or subcuneate at the base, coarsely, obtusely, and irregularly serrate. Rarely the third pair are lobed and a detached portion may sometimes be seen on the petiole.

Collinsia parviflora, *Dougl.*

Hypocotyl very similar to last species.

Cotyledons very similar to those of C. bicolor, almost orbicular, emarginate, obtuse, dark green, reddish below, very indistinctly one-nerved.

Stem with primary internodes very slightly developed.

First leaves showing a tendency to become trilobed, slightly emarginate, ovate, obtuse, petiolate, minutely pubescent, dark green stained with purple beneath, indistinctly pinnatinerved.

Collinsia multicolor, *Paxt.*

Hypocotyl as in C. bicolor, but 3–5 cm. long, and light green or colourless.

Cotyledons fleshy, ovate or almost rotund, emarginate, sometimes almost cordate at the base, glabrous except on the petioles, dark green, pinnatinerved like the leaves, with prominent venation.

Stem.—1st internode 4–5 mm. long.

First leaves ovate-oblong, emarginate, crenate, petiolate, pubescent, light green, pinnatinerved.

Mimulus luteus, *L.* (fig. 560).

Primary root normal.

Hypocotyl short, tapering insensibly into the root, glabrous.

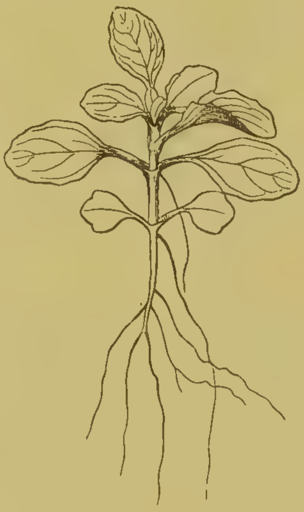

FIG. 560.—*Mimulus luteus.* Nat. size.

Cotyledons triangular, obtuse, incipiently tridentate near the apex with the middle tooth much the largest and longest, traversed longitudinally with an indistinct midrib (no other nerves discernible when fresh), glabrous, light green; lamina 4–5 mm. long, 3·5–4·5 mm. wide; petiole channelled above, slender, 2·5–4 mm. long.

Stem herbaceous, erect, terete, pale green, glabrous; primary internodes undeveloped unless the seedlings are crowded when more or less elongation takes place. Adventitious roots are frequently emitted from the stem where in contact with the soil.

Leaves simple, radical and cauline, opposite, exstipulate, petiolate, alternately penninerved, with the nerves incurved and uniting with those above them, light green and punctate on the upper surface, paler beneath, glabrous or thinly hairy on the same plant; petioles glabrous, channelled above, dilated at the base and connate.

First and second pairs variable; in seedlings with sufficient room to develop they are deltoid, obtuse, obscurely or obsoletely dentate, with a prominent midrib and a few alternate incurved lateral nerves; in crowded seedlings they are oval.

Torenia Fournieri, *Lind.* (fig. 561).

Primary root normal, short, tapering, giving off short lateral rootlets, annual.

Hypocotyl soft, herbaceous, erect, terete, 1·5 cm. long.

Cotyledons petiolate, persistent; limb triangular-emarginate, subtruncate at the base, 4 mm. long, 6 mm. wide; petiole 2 mm. long.

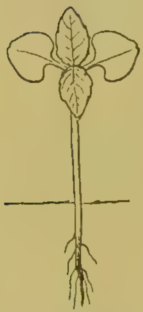

Fig. 561. *Torenia Fournieri.* Nat. size.

Stem erect, square with acute angles, thickened at the nodes and ciliate at the angles, succulent, pale green; 1st internode 6 mm. long; 2nd 1·2 cm.; 3rd 2·6 cm.; 4th 3 mm.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate, triangular, or triangular-ovate, acute, acutely penninerved, with the nerves sunk on the upper side, and prominent beneath, pubescent on both surfaces, gradually increasing in size from the seedling stage of the plant to the adult; average size of leaf 2·2 cm. long, 8–10 mm. wide; petioles channelled above, convex beneath, pubescent, increasing in length from seedling to middle of stem in the adult plant, then again becoming shorter; average length about 1·5 cm.

Veronica arvensis, *L.* (fig. 562).

Ovary two-celled, many-ovuled; ovules amphitropous on axile placentas; micropyle superior.

Fruit a capsule, obcordate, much compressed laterally, keeled, glabrous except on the keel which is coarsely hairy, two-celled, many-seeded, dehiscing at the apex with four valves.

Seed peltate, broadly oblong, or of various outlines, convex dorsally, flattened ventrally with an oblong or obovate, elevated hilum, imbricating and lying obliquely to the flattened sides of the ovary, pale straw- or almost amber-coloured; micropyle at the upper end.

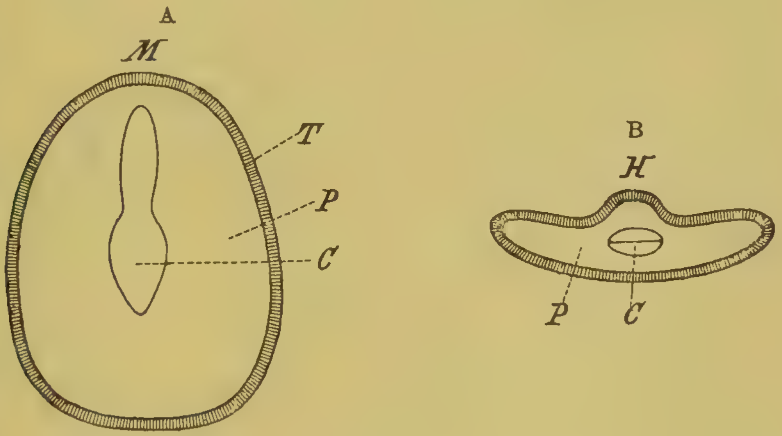

FIG. 562.—*Veronica arvensis*, × 30. A, longitudinal section of seed: *M*, micropyle; *T*, testa; *P*, endosperm; *C*, cotyledon. B, transverse section of seed: *P*, endosperm; *C*, cotyledon; *H*, hilum.

Endosperm in the mature seed copious, fleshy, white, embedding and surrounding the embryo.

Embryo rather small, considerably shorter than the endosperm, colourless; cotyledons ovate, obtuse, plano-convex, lying in the broad plane of the seed, with their backs to the placenta; radicle terete, obtuse, pointing to the micropyle at the upper end of the seed, somewhat longer than the cotyledons, and narrower or thinner.

Veronica Buxbaumii, *Ten.* (fig. 563).

Ovules pendulous, horizontal or ascending, anatropous or nearly so, with the micropyle close to the hilum, and consequently superior, horizontal or inferior.

Capsule much compressed laterally, bifid, with widely diverging, obtuse, keeled lobes, glandular-hairy all over, dehiscing when mature by four apical valves, with about eight to twelve seeds in each of the two cells, attached by a very short pale or colourless funicle to papillose projecting processes of the placentas which are deep green before the capsule dries up.

Seed oblong, rounded at both ends, or somewhat narrowed to the basal and attached end, transversely ridged and grooved on the dorsal and convex aspect, concave on the sides facing one another, and containing or surrounding the raphe and funicle in this groove, glabrous, white before maturity; raphe lying along the median line in the groove; funicle very short; micropyle contiguous to, but a little higher up than the hilum, on, or towards the external aspect.

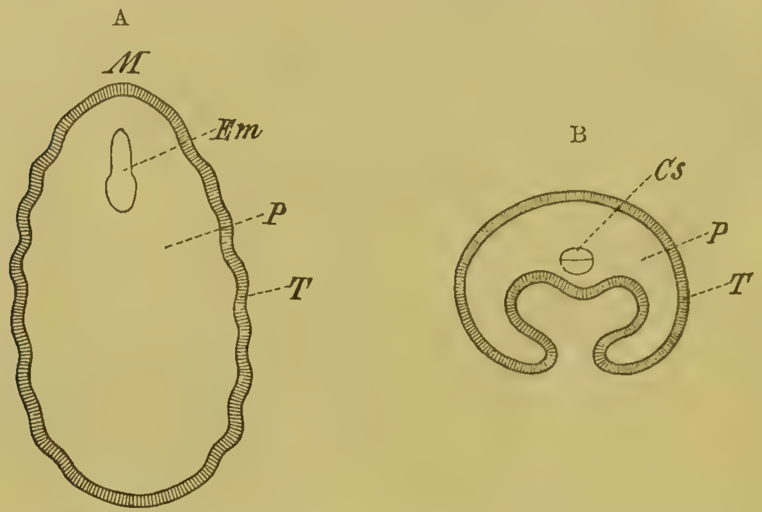

Fig. 563.—*Veronica Buxbaumii*, × 20. A, longitudinal section of seed. B, transverse section of seed: *M*, micropyle; *Em*, embryo; *P*, endosperm; *Cs*, cotyledons; *T*, testa.

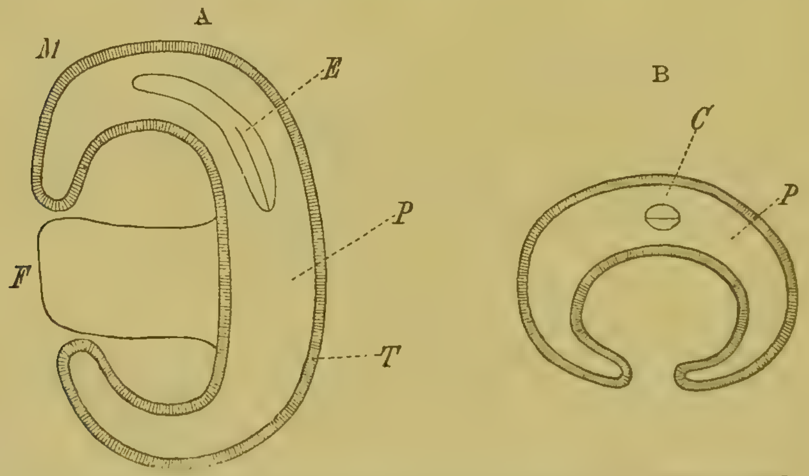

Fig. 564.—*Veronica hederæfolia*, × 15. A, longitudinal section of seed. B, transverse section of seed: *F*, funicle; *E*, embryo; *P*, endosperm; *T*, testa; *M*, position of micropyle; *C*, cotyledons.

Endosperm in the mature seed copious, fleshy, white, occupying nearly the whole seed.

Embryo small, straight, colourless, at right angles to the placenta; cotyledons broadly ovate, obtuse, entire, plano-convex, lying in the broader way of the seed with their backs to the raphe on one side and to the dorsal aspect on the other; radicle oblong, obtuse, pointing to the micropyle, but some little distance from the extreme apex of the seed, slightly longer than the cotyledons.

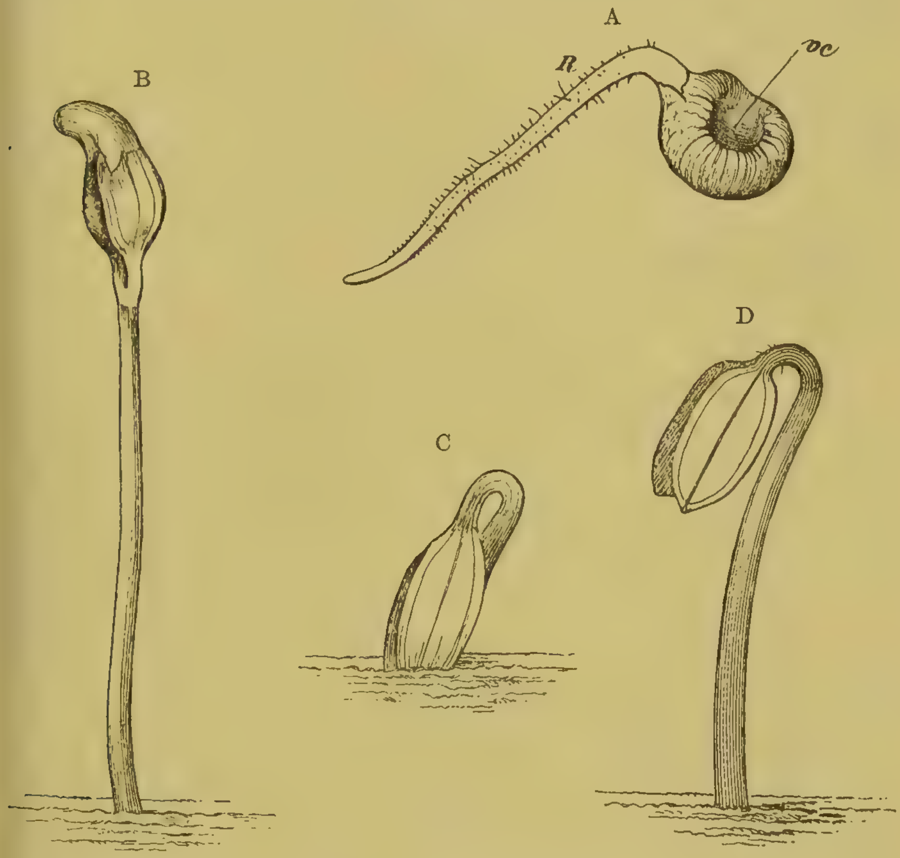

Fig. 565.—*Veronica hederæfolia.* A, seed germinating: *R*, radicle; *vc*, ventral cavity of seed, × 4. B, another seedling, × 4. C, seedling, × 4, showing mode of germination when the seed is well buried. D, another stage of C, × 4.

Veronica hederæfolia, *L.* (figs. 564–66).

Ovary with each of the two cells two-ovuled; ovules peltate, amphitropous; micropyle superior.

Capsule broadly obovoid or subglobose, turgid and slightly emarginate, shallowly grooved along the side where the union of the carpels forms a double partition, with a slender filiform ridge along the dorsal suture, and shallowly grooved or not in that part, glabrous, each cell one- or two- (generally two-) seeded, dehiscing at the dorsal suture and separating or breaking away from the placental column.

Seed in the early stage forming a little curved or reniform papilla suspended by a colourless hilum, increasing greatly in length and breadth but not thickness, till it becomes an oblong, flattened body. Growth continues in the middle and dorsal region, but not at the edges, until the seed assumes an oblong-sphæroid form, peltate on the funicle and concave on the ventral aspect, completely enclosing and hiding the colourless funicle, transversely and shallowly grooved towards the margin, pale amber-coloured or nearly white, glabrous; micropyle at the upper end of the seed and external to the ventral cavity; funicle stout, colourless, obliquely ascending, enclosed by the involute edges of the seed; hilum ventral in the cavity.

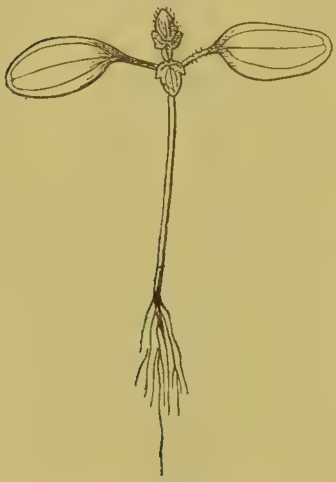
Fig. 566.
Veronica hederæfolia.
Seedling, nat. size.

Endosperm in the mature seed copious, fleshy, firm, white.

Embryo small, slightly curved in conformity with the curvature of the seed, embedded in the centre of the endosperm at the upper end of the seed, colourless; cotyledons oblong, obtuse, entire, trinerved, plano-convex; radicle terete, obtuse, a little longer than the cotyledons, close to the micropyle at the upper end of the seed but completely surrounded by the endosperm.

Germination.—Seeds sown on the 29th of June commenced to germinate on the 7th of December.

An early stage (fig. 565, A) shows the radicle pushed out from the seed and furnished with root-hairs; the ventral cavity of the seed is very conspicuous.

Three days later (fig. 565, B) the hypocotyl is straight, thinly hairy at the very top and on the petioles of the cotyledons. The latter are trinerved, glabrous except the petioles, and have nearly got out of the membranous, now empty testa.

When the seed is moderately well buried in the soil, the radicle pushes out first and fixes the plant in the soil, then the hypocotyl arches and in straightening pulls the cotyledons out of the seed (fig. 565, C).

Two days later (fig. 565, D) the cotyledons get clear out of the seed, an easy process when the seed is properly covered with soil. The hypocotyl elongates greatly meanwhile.

Veronica serpyllifolia, *L.* (fig. 567).

Ovules numerous, pendulous, horizontal, ascending and erect from an elevated, knob-like axile placenta, anatropous; micropyle superior, horizontal or inferior, and next to the hilum.

Capsule broadly obcordate, much compressed laterally and keeled, glandular-pubescent on the keel, otherwise glabrous, two-celled, with the septum in the narrow way of the fruit, many-seeded, dehiscing by four valves when mature, tipped with the slender persistent style which is much longer than the apical notch.

Seeds broadly oval-oblong or obovate-oblong, much compressed laterally, obtuse-edged, very small and numerous, pale-coloured, yellowish-white just before maturity; testa thin; raphe and chalaza on one of the flattened faces; funicle very short; hilum and micropyle basal.

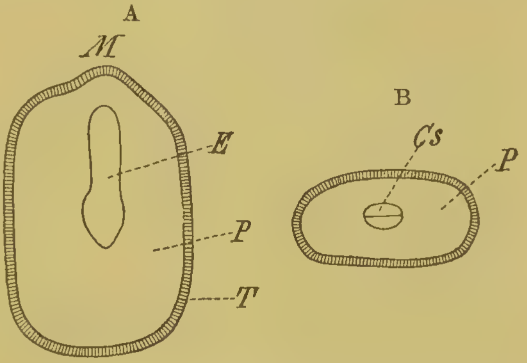

FIG. 567.—*Veronica serpyllifolia*, × 40. A, longitudinal section of seed. B, transverse section of seed: *M*, micropyle; *E*, embryo; *P*, endosperm; *T*, testa; *Cs*, cotyledons.

Endosperm in the mature seed copious, fleshy, whitish.

Embryo small, straight, colourless, about three-fourths the length of the endosperm; cotyledons ovate, obtuse, entire, plano-convex, lying in the broad way of the seed with their edges to the axis or placenta; radicle terete, obtuse, slightly longer than the cotyledons, embedded in the endosperm near the hilum.

Veronica salicifolia, *Forst.*

Ovary as in V. arvensis.

Capsule ovate or ovoid, laterally compressed, pubescent especially towards the edges, two-celled, many-seeded, dehiscing for more than half its length into four valves, each of which is acute or subacuminate and more or less conspicuously trinerved.

Seed peltate, closely resembling that of V. arvensis.

Endosperm copious, occupying almost the whole interior of the seed, whitish.

Embryo small, less than half the length of the endosperm, straight, otherwise as in V. arvensis.

Seedling.

Primary root slender, flexuose, soon exceeded in length by the lateral rootlets.

Hypocotyl short or indistinguishable from the root.

Cotyledons small, ovate, obtuse or subacute, petiolate, glabrous; lamina 2·5 mm. long, 2 mm. wide; petiole grooved above, ·5 mm. long.

Stem shrubby, erect, terete, pubescent in the seedling, glabrous in the adult plant, pale green, shining; 1st and 2nd internodes 2·5–4 mm. long; 3rd 2·5 mm.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate, glabrous and shining on both surfaces, coriaceous, evergreen, deep green above, pale beneath, obscurely alternately penninerved and reticulate; petioles short, grooved on the upper side, semiamplexicaul, glabrous.

First pair lanceolate-elliptic, obtuse, entire.

Second pair lanceolate-elliptic, entire, subacute.

Third pair lanceolate-elliptic, acute, with one or two serratures on each side.

Intermediate forms are lanceolate, acute, serrate.

Ultimate leaves oblong-lanceolate, acuminate, acute or tipped with a mucro, serrulate, minutely pubescent or scaberulous at the margin, as are the intermediate forms, but not those in the younger seedling stage, three- or faintly five-nerved in the lower half.

Veronica Waldsteiniana, ? *Hort.*

Hypocotyl short, erect, terete, glabrous, 1–1·5 mm. long, light green or colourless.

Cotyledons ovate, obtuse, emarginate, membranous, petiolate, glabrous, green, indistinctly one-nerved.

Stem erect, terete, herbaceous, hairy; 1st internode ·75–1 mm. long; 2nd shorter.

First leaves simple, cauline, opposite, decussate, broadly ovate, obtuse or subacute, serrate, hairy, petiolate, exstipulate, light green, distinctly and alternately pinnatinerved.

Veronica sp. (V. hederæfoliæ aff.).

Primary root tapering downwards, fibrous, annual.

Hypocotyl erect, terete, pale green or colourless, glabrous at the base and hairy upwards, elongating in heat to 6 or 7 cm.

Cotyledons orbicular, foliaceous, emarginate, with a glandular mucro in the sinus, trinerved from the petiole to the apex where the lateral nerves unite with the midrib immediately below the mucro, with a few indistinct reticulations outside and inside of the strong laterals, glabrous, dark green above, paler beneath; lamina 1·2 mm. long, and as wide; petiole slender, semiterete, channelled above, subperfoliate, hairy, pale green, about 1·7 cm. long.

Stem erect, more or less quadrangular, with obtuse angles, pale green, densely hairy or subvillous; 1st internode 1·5 cm. long.

Leaves simple, cauline, opposite, exstipulate, petiolate, densely hairy on both surfaces, trinerved from the base in the seedling, light green; petiole short, channelled above, densely hairy.

First pair rotund, obtuse, cordate at the base, crenate-dentate with obtuse teeth tipped with a glandular mucro, trinerved from the petiole to the apex, with the primary lateral nerves running into a tooth on each side of the apical one, and short lateral branches running into the other teeth from the primary lateral nerves.

Ultimate leaves rotund-reniform or reniform, five- to seven-nerved, obtusely five- to seven-toothed, rarely nine-toothed, coarsely hairy on both surfaces but not glandular; teeth tipped with a glandular mucro. Bracts similar to the leaves and not much smaller, falling short of the peduncles.

Fruit didymous, turgid and furrowed along the midrib of the carpels, not carinate, densely hairy but not glandular, with a sunk cavity at the apex in which the persistent style is situated, two-celled, each cell two-seeded.

Pedicularis sp.

Root small, yellowish, with a few rootlets and root-hairs.

Hypocotyl 5 mm. long, ·5 mm. thick, terete; hairs purplish-red.

Cotyledons equal, 4 mm. long including the glandular-ciliate, purplish petiole, 2 mm. wide, ovate, rounded at the base, obtuse at the apex, entire, obscurely nerved, glandular-ciliate, thin, purplish.

Stem with the primary internodes undeveloped.

Leaves simple, once, twice, or still further pinnately cut, radical and cauline, apparently opposite in the seedling, exstipulate, petiolate, with venation conforming to the divisions, hairy.

First pair oblong-ovate, shallowly pinnatifid with rounded serrulate lobes, 1 cm. long including the petiole, and 4 mm. wide.

GESNERACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 990.

Fruit and Seed.—The ovary is inferior, half or wholly superior and one-celled with two parietal placentas which are bifid and slender or strong, and consist each of two broad revolute plates approaching one another in the centre of the cell, imperfectly dividing it into two or four locelli ; rarely do they cohere at the base or beyond the middle of the cell as in Monophyllæa and Loxophyllum. The ovules are generally very numerous, and densely cover the placentas on all sides or at their margins only ; they are also minute and anatropous. The fruit is capsular, rarely fleshy, and in the Gesnereæ dehisces by two valves between the persistent calyx-lobes, or rarely at a dorsal slit at the base as in the genus Monopyle. In the tribe Cyrtandreæ it is indehiscent, or bursts transversely, sometimes by two valves along the middle of the carpels, or at the placentas. In other cases it is four-valved with the valves bearing both divisions of the placentas on their middle or a half of the placentas on their margins ; the valves rarely become entirely separated from the placentas. The seeds are very numerous and minute, pendulous or horizontal and ovoid, oblong, fusiform or linear with a striated or reticulate testa drawn out into a short point or a long thread-like process at either end. Endosperm is more rarely scanty and fleshy, copious or absent. The embryo is straight and nearly as long as the endosperm when that is present, with short cotyledons and a radicle pointing to the hilum.

Seedlings.—The cotyledons of seedlings in this Order are always very small unless one or both become foliaceous by intercalary growth. Those of Sinningia speciosa are small, rotund and never attain any great size. Gesnera macrantha has broadly ovate or triangular cotyledons, glandular on both surfaces and showing a midrib only. The hypocotyl commences to thicken soon after germination and forms a fleshy, globular and persistent rootstock, as does also Sinningia speciosa. The first pair of leaves in Gesnera macrantha are roundly ovate and entire; the second pair are roundly oval with a few crenatures; and the third pair are cordate-ovate and crenate. All the three pairs are developed close to the ground.

A very curious case presents itself in the different species of Streptocarpus. The cotyledons are quite normal for some time after germination. They are small or even minute, orbicular, entire, sessile, and thinly glandular-hairy, or they develop a very short petiole and become roundly ovate or triangular, showing a midrib, but no other venation. The different stages of growth after germination are well shown by a seedling from S. Rexii crossed with S. lutea (fig. 568). There are two or not infrequently three cotyledons. The first leaf is developed from one of them by intercalary growth which sets in at the base of the lamina and continues for a considerable time. The original and true lamina of the cotyledon is carried up on the apex of the leaf, and the tip is therefore the oldest part. Finally it withers and dies away, and the apex of the leaf dies away from above downwards in the same fashion. In the early stage the leaf as a whole becomes obovate, then broadly ovate and obtuse. It retains this shape for some time; but ultimately becomes oblong or strapshaped with a more or less cordate base, attaining a length of six to ten inches or more. This type of Streptocarpus develops a rosette of leaves, the second one of which seems to arise from the short, thick and fleshy petiole of the first. S. Rexii *var.* floribundus is a strong-growing form of the species. In its early stages it behaves in the same way as the last, the first leaf being developed from one of the cotyledons by intercalary growth at the base. A rosette of leaves is ultimately formed, and when the plants are strong the leaves vary from six to twelve inches or more in length. The cotyledons of S. Dunnii are also perfect and normal in the early stages, small, rotund and entire. The only leaf the plant produces is developed from one of the cotyledons and becomes oblong, narrowed toward the apex, incurvi-penninerved, lobulate and dentate, cinereous above from the presence of grey hairs, and rusty beneath with reddish ones; it varies from twelve to thirty-six inches in length, and nine to twenty inches in width at the broadest part.

Gesnèra macrantha, *Spr.*

Primary root slender, terete, apparently branching little if at all, and soon superseded by strong branching lateral rootlets abundantly furnished with root-hairs, all orange-red.

Hypocotyl short, globose, fleshy, pale reddish, increasing rapidly, and losing its epidermis which becomes rent into longitudinal stripes, 2–4·5 mm. in diameter sixty-six days after sowing the seed, forming the persistent rootstock of the plant.

Cotyledons very small, broadly ovate or triangular, obtuse, entire, petiolate, glandular-pubescent on both surfaces, and ciliate, pale green with a midrib discernible at the base only by transmitted light; lamina suddenly narrowed into the petiole, apex obtuse, 2·25–2·5 mm. long and the same in width; petiole about 1–1·25 mm. long.

Stem herbaceous, erect, terete, densely glandular-hairy, or almost villous, dying down annually to the persistent tuberous rootstock; 1st internode ·5–1 mm. long; 2nd and 3rd similar.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately incurvinerved with the nerves more or less united at their apex or forming intramarginal not very conspicuous reticulations, softly hairy or villous especially on the upper surface with shaggy whitish hairs; petiole semiterete, channelled above, densely hairy or villous with more or less glandular hairs.

First pair of leaves small, broadly ovate or rotund-ovate, obtuse, entire, with a midrib and a few alternate incurved nerves.

Second pair much larger, oval or rotund-elliptic, obtuse, entire or obsoletely crenate-dentate, with a more evident venation.

Third pair cordate-ovate, obtuse, crenate.

Streptocarpus Rexii, *Lindl.*, × **S. lutea,** *C. B. Clarke* (fig. 568).

Primary root slender, tapering, with a few lateral rootlets.

Hypocotyl extremely short and fleshy, merging into the root, or hardly developed.

Cotyledons small, rotund, shortly petiolate, subtruncate at the base, apparently nerveless, light green, thinly hairy; lamina about 1·5 mm. in diameter; petiole 1 mm. long.

One of these cotyledons afterwards becomes the first true leaf and is very persistent, attaining a large size. The other one persists for some months but never gets larger.

The above is the usual origin of the first leaf, but seedlings frequently occur having three cotyledons; from one of which the first leaf is produced apparently at right angles to the others which soon cease to enlarge.

Stem very short, fleshy, becoming swollen and tuberous, appearing continuous with or forming a petiole to the first leaf, and carrying it above the other cotyledon.

Leaves few, simple, radical, alternate, exstipulate, sessile, alternately and ascendingly penninerved, densely hairy on both surfaces, but especially so on the nerves beneath, with fleshy, crystalline, bulbous-rooted hairs.

No. 1. Originally ovate, obtuse, entire, apparently nerveless, afterwards alternately penninerved, becoming oblong, and crenate, then panduriform by a wide development near the base, below which it is cordate and suddenly cuneate to the stalkless base, obtuse at the tip and thinly hairy denoting the persistence of the cotyledon, subrugose, with the primary nerves sunk above, prominent beneath and not terminating directly in the teeth.

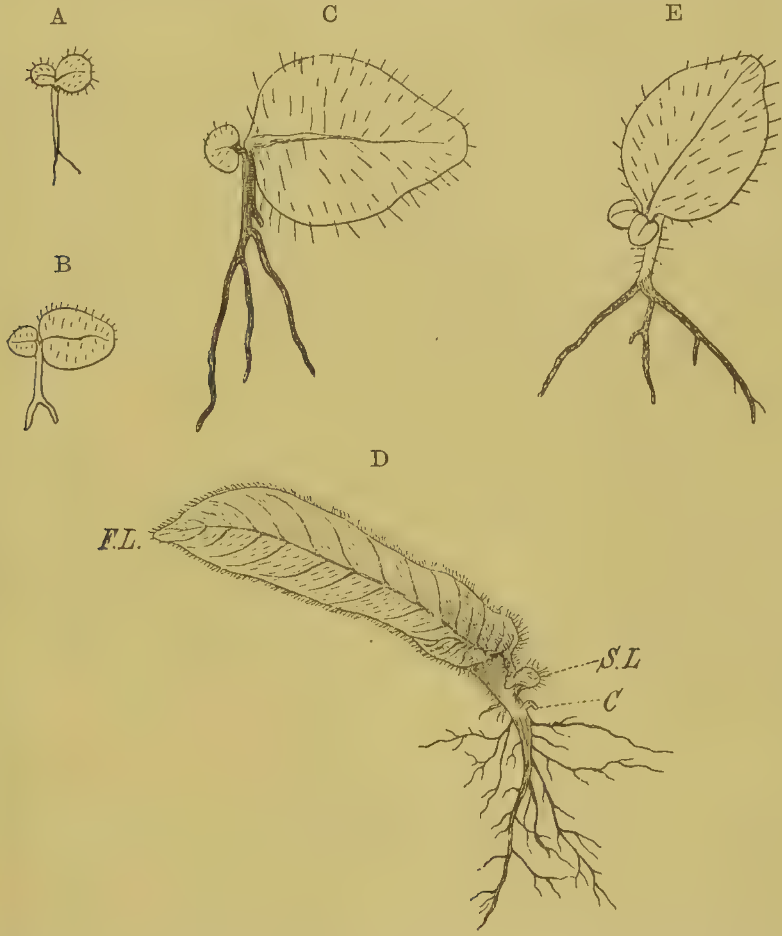

FIG. 568.—*Streptocarpus Rexii* × *S. lutea.* A, B, C, different stages of seedling, × 5. D, older seedling, nat. size: *FL*, first leaf; *SL*, second leaf; *C*, persistent cotyledon. E, Seedling with three cotyledons, from one of which the first leaf is developed, × 5.

No. 2. Originating at the very base of the first one, and opposite or oblique to it.

Streptocarpus Dunnii, *Hook. f.*

Cotyledons perfect and normal after germination, rotund, entire, growing until they reach a certain size (still very small) when one ceases and the other develops into a large leaf as described below.

Stem very short, fleshy, and scarcely distinguishable from the base of the leaf.

Leaf developed from one of the cotyledons, solitary, radical, simple, ovate, elongate, obtuse, obscurely crenate, very persistent and becoming large, ovate, acuminate, obtuse, cuneate at the base, but compressed there and appearing cordate where it suddenly widens, lobulate, ultimately oblong, coarsely dentate, alternately penninerved, the nerves not entering the lobes directly, but uniting with a strong branch of the nerve immediately above, and forming a span which is less than a right angle, reticulate, rugose, fleshy, densely covered with short fleshy adpressed pale grey hairs with a few reddish ones intermixed, cinereous above, rufous beneath from the intermixture of pale and red hairs, with prominent projecting nerves and prominently reticulated.

Ultimately the leaf is oblong, obtuse, slightly narrowed upwards, tapering at the base and appearing cordate by the contiguous sides, doubly dentate or lobular-dentate with gland-tipped teeth, alternately incurvi-penninerved, strongly rugose and reticulate, glandular-pubescent on both surfaces, cinereous above, rufous or reddish beneath, twelve to thirty-six inches long and nine to twenty inches at the broadest.

BIGNONIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1026.

Fruit and Seed.—The ovary is superior, two-celled, with two parallel, distant or contiguous, but distinct placentas, adnate to the septum, but sometimes though rarely one-celled with two parietal bifid placentas. The ovules are numerous, horizontal, anatropous, and arranged in a single series or rather irregularly in one to many series. The fruit is capsular, dehiscing along the middle of the carpels or breaking away from the septa; or it is fleshy, indehiscent and more or less filled with fibrous, spongy or pulpy placentas. The seed is transverse to the longitudinal axis of the fruit, and inserted on either margin of the septa in one or many series or scattered over the septa or drawn-out placentas. It is more or less compressed vertically, often flat, and often girt with a hyaline, rarely opaque wing which is broad, narrow or interrupted in many cases at the base and apex. The testa in the centre of the wing is membranous or leathery, sometimes thickened, and at the apical end of the seed or at the chalaza it is intruded or pushed into the cavity of the seed, sometimes almost dividing it into two cells, thus accounting for the very prevalent bifid character of the cotyledons. Endosperm is wanting. The embryo is flattened or rarely thickened, with flat or rarely folded, bifid, emarginate or rarely entire cotyledons, which are often broader than long. The radicle is always short, often very short, and horizontal. Some exceptions occur in the Order, as in Eccremocarpus and in the Crescentieæ where the ovary is one-celled with two parietal placentas. The fruit is often abnormal in various ways in the tribes Jacarandeæ and Crescentieæ, and is subfollicular in Amphicome and Incarvillea. The seed is furrowed or the testa partly invaginated in species of Stereospermum, and perfectly intruded between the cotyledons in Kigelia. The seeds are few and thick in Argylia.

All the seeds noticed are much flattened and winged; they may be divided into those which have the wing continuous round the apex of the seed, and those in which it is absent at the base and apex. Dolichandrone Cauda-felina is the only typical instance of the latter observed. The seed is oblate, perfectly straight at the base and apex, while the testa is produced into a wing at either side, and obliquely truncate at the two ends. The portion of the seed containing the embryo occupies the whole of the centre. This peculiar form of the seed is due to that of the fruit which is a long, narrow pod with the seed occupying the whole width of the cavity. The embryo is large, nearly as wide as the seed, and is oblate, with the cotyledons deeply emarginate or shallowly bifid at the apex. The lobes are rounded in conformity with the seed, and the extremely short radicle occupies a shallow basal notch. The latter is due to the presence of the radicle which has to be accommodated. The apical emargination or fissure is due to the intrusion of the testa at that point where the chalaza is situated, as explained under Bignonia speciosa. Catalpa speciosa most nearly approaches to the above, inasmuch as the seed is oblate and strongly winged at either end, but the wing is continuous at the apex, though not very wide, and is also continuous at the base except for a deep notch at the hilum. It is deeply fringed or lacerated at either end. The greatly widened seed and its short longitudinal axis are due to the narrowness of the long, slender, cylindrical fruit. The embryo is oblate and much constricted in the middle, almost dividing the cotyledons into two equal suborbicular portions. The radicle occupies one notch.

A good type of a seed with a continuous wing is furnished by Pithecoctenium Aubletii. The thickened portion of the testa containing the embryo is not central, and the really membranous portion is absent at the linear or oblong hilum. The embryo is oblate, deeply constricted in the middle with open notches and an extremely short radicle. Oroxylum indicum is another instance of a broadly winged seed, and the wing is slightly but irregularly dentate at the margin. The embryo differs from that of the last by having the lobes imbricated at the apical fissure, almost hiding the latter. The radicle is deeply seated in the basal notch which is otherwise open. The fruit of Bignonia speciosa is oblong, flattened and densely covered with tubercular spines or emergences. The seeds are arranged in two rows in each cell upon widely separated placentas, and are much imbricated, the lower ones always overlapping the upper. They are oblate and broadly winged; and the embryo is constricted in the middle with rather wide notches. Bignonia insignis differs by having its cotyledons fleshy, amalgamated in one piece, and subterranean even after germination. The embryo, however, conforms in shape to the other species in all general particulars. Pajanelia multijuga has rather narrowly winged seeds. The embryo is deeply bifid at the apex but hardly notched at the base, while the radicle is inconspicuous. It is not central. This also occurs in Stereospermum suaveolens, but the wing is broader at each side than it is at the base or apex of the seed. The embryo is similar to that of the last.

The fruit of Incarvillea Olgæ is a linear, slender and terete capsule. The seeds are pendulous in two rows, and imbricated, the uppermost being outermost; they are also numerous and small. The wing is continuous except at the base. The embryo is central or nearly so, with oval, shallowly emarginate cotyledons distinctly auricled at the base. The radicle projects considerably beyond the base of the auricle. The fruit of Eccremocarpus scaber is an inflated capsule ovate-oblong in outline. The seed is orbicular and compressed with the wing continuous round the margin except at the hilum where there is a small notch. That part of the testa in which the embryo is situated is black and obovate in outline. The embryo is broadly obovate or oblate in outline when mature, and the cotyledons are suborbicular and entire. The oblate outline is more developed after germination. This species is one of the few cases occurring in the Order of a one-celled ovary with two parietal placentas.

Seedlings.—About half a dozen different types of cotyledons have come under my notice, but only one of them is of very frequent occurrence, and most of the others are more or less evidently modifications of it. This leading type may be represented by Catalpa Kæmpferi (fig. 571). The cotyledons are oblate and deeply bifid with rounded entire diverging lobes. The midrib terminates in the sinus, and represents the real length of the lamina. The lobes are lateral developments dependent upon the shape of the seed, and that again is due to the shape of the capsule which is long, narrow, subcylindrical and pod-like. The seeds being inserted on the placenta at right angles to the longitudinal axis of the capsule, they attain a larger size than they otherwise could, by growing in breadth. The cotyledons therefore develop the lateral lobes, which gives them their characteristic form, in order to occupy the additional space afforded them, right and left of their longitudinal axis. The cotyledons of C. syringæfolia are divided nearly to the base of the lamina. Those of C. speciosa are not quite so deeply divided, but are otherwise similar and show the venation. They are trinerved from the base, and the lateral nerves run down the centre of the lateral lobes, giving off a few strong branches. The midrib forks or gives off two lateral branches close beneath the sinus, and these pass along the contiguous edges of the lobes a short way within the margin. The first pair of leaves of C. Kæmpferi are ovate followed by two subcordate pairs. All the three pairs in C. syringæfolia are cordate. The first pair in C. speciosa are subcordate followed by three cordate pairs. In all cases these primary leaves are slightly dentate. The ultimate leaves are entire or sometimes shallowly trifid in C. Kæmpferi.

The cotyledons of Tecoma stans closely correspond to those of Catalpa syringæfolia and are also trinerved. The first five pairs of leaves are however lanceolate, acuminate and sharply serrate. The cotyledons of Tecoma Manglesii are similarly divided, but without discernible venation in the fresh state, and the lobes overlap one another at the sinus. The first pair of leaves are small, ovate and entire. The second pair are digitately trifoliolate, and the third pair pinnately trifoliolate, both with more or less toothed leaflets. The fourth and fifth pairs have five leaflets; the sixth and seventh have seven leaflets; and the eighth and ninth have nine. The cotyledons of Spathodea adenophylla may be compared with those of Tecoma stans. The first pair of leaves are oblong-lanceolate and serrate.

A slight modification of the above is met with in Spathodea campanulata (fig. 572). The cotyledons are oblate and shallowly bifid or deeply emarginate. An obscure midrib is the only venation apparent. The first three pairs of leaves are elliptic, serrated except in the lower third of their length, and hairy. Tecoma radicans differs only in showing three branching nerves in the cotyledons. Those of Kigelia pinnata have five branching nerves from the base. The hypocotyl is subterranean or very short; and the first three leaves are rather large, lanceolate-oblong and serrate. The cotyledons of Eccremocarpus scaber (fig. 574) are broadly emarginate with a tooth in the notch, trinerved at the base with a pair of strong lateral nerves about the middle, thinly glandular-hairy on both surfaces and glandular-ciliate. The hypocotyl is also finely glandular-pubescent. The first pair of leaves are rotund and five- to seven-angled with a strong nerve running into each angle or tooth. The ultimate leaves are bipinnatisect.

Crescentia Cujete (fig. 575) represents a third type having broadly oblong-ovate, emarginate, three- or faintly five-nerved cotyledons. The first pair of leaves are elliptic, and the ultimate ones are greatly elongated and vary from linear-lanceolate to elliptic-lanceolate.

The cotyledons of Pithecoctenium muricatum (fig. 570) are triangular, slightly emarginate, and obsoletely trifid. The first two pairs of leaves are pinnately trifoliolate with elliptic leaflets.

A fifth type is met with in Incarvillea Olgæ (fig. 573) which has triangular, emarginate cotyledons, truncate at the base and faintly multinerved or striated. The two first pairs of leaves are ovate with a few serratures about the middle. I. compacta differs in having reniform, trinerved, broadly and shallowly emarginate cotyledons. The first leaf is oblong, slightly emarginate, cordate at the base, but otherwise entire and unsymmetrical.

The sixth type occurs in Bignonia insignis (fig. 569) and is the only instance of the kind observed. The cotyledons are thick, fleshy, and amalgamated in one piece, and remain in the seed after germination, keeping fresh for many weeks even if they fail to germinate. The first pair of leaves are small and scale-like ; the second, third and fourth pairs are cordate, foliaceous and simple ; while the fifth pair have each a pair of leaflets and a terminal tripartite hooked tendril.

Bignonia insignis, *Hort.* (fig. 569).

Hypocotyl undeveloped or short and subterranean.

Cotyledons oblate, more or less emarginate, deeply subterranean and remaining in the oblate winged seeds until these decay, shortly petiolate, with the petioles unequally developed to accommodate the exit of the plumule.

Stem in the early stages erect, terete, finely and minutely pubescent, pale, dull or brownish-green, sometimes rosy red, ultimately woody and climbing ; 1st internode 2–2·4 cm. long ; 2nd 8–14 mm.

Leaves cauline, opposite, decussate, exstipulate, petiolate, alternately incurvinerved and reticulate, glabrous except at the margin and on the principal nerves where they are shortly and minutely pubescent, deep green above, very pale or whitish beneath; petiole terete, with a slender channelled line on the upper side, densely and minutely pubescent, articulated with the stem, and slightly thickened at the insertion.

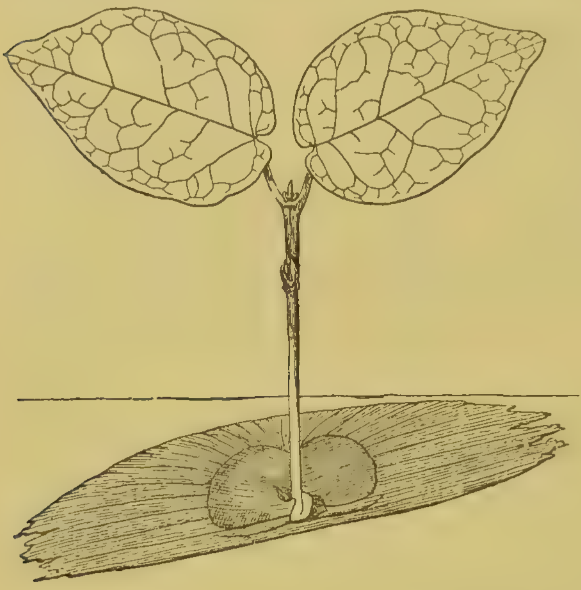

FIG. 569.—*Bignonia insignis.*
Nat. size.

First pair of leaves reduced to lanceolate-acuminate, pale green, minutely pubescent scales.

Second and third pairs cordate-ovate, apiculate, entire, foliaceous.

Fourth pair simple but sometimes articulated with the petiole.

Fifth pair compound with one pair of leaflets, and terminating in a tripartite, slender, hooked tendril by which the plant is enabled to climb.

Pithecoctenium muricatum, *Moc.* (fig. 570).

Hypocotyl erect, terete, minutely pubescent, 1–1·6 cm. long, light green.

Cotyledons broadly ovate, obtuse, slightly emarginate, obsoletely and obtusely tri-lobed or -angular, increasing considerably in size after emerging from the seed, petiolate, minutely pubescent, dark green, five-nerved; petioles short, thin, pubescent, deeply furrowed on the upper face.

Stem erect, terete, herbaceous, ultimately woody, pubescent; 1st internode 8–10 mm. long; 2nd about the same.

First leaves cauline, opposite, compound, trifoliolate, petiolate, exstipulate, pubescent; leaflets obovate-oblong, obtuse, entire or minutely emarginate, petiolulate, often unsymmetrical, ciliate, green, pinnatinerved; petioles long, thin, pubescent, channelled on the upper side.

Catalpa Kæmpferi, *Sieb. et Zucc.* (fig. 571).

Primary root normal, tapering, flexuose, and abundantly furnished with lateral rootlets.

Hypocotyl woody, erect, terete, finely pubescent, purplish, 1–2 cm. above the soil.

Cotyledons deeply bipartite, with rotund, entire, divaricate segments; petiole somewhat flattened horizontally, or slightly convex on both surfaces, shallowly grooved above, finely pubescent; lamina glabrous, 7 mm. long, 13 mm. from tip to tip of the lobes.

Stem woody, erect, terete, finely pubescent, pale green or tinged with purple; 1st internode 11·5 mm. long; 2nd 8·5 mm.

Leaves simple, cauline, opposite, or verticillate in whorls of three, exstipulate, petiolate, pubescent above, at the margins and on the nerves beneath or all over, three- to five-nerved at the base (the two anterior of the basal four much the stronger and running into the side lobes of the leaf in the adult plant), rather dark green above, and stained with purple when unfolding, paler beneath; petioles of the first pair slightly grooved above, of the second pair flattened above, of the third pair terete or subterete, pubescent—of the adult leaves terete or sometimes slightly channelled on the upper half.

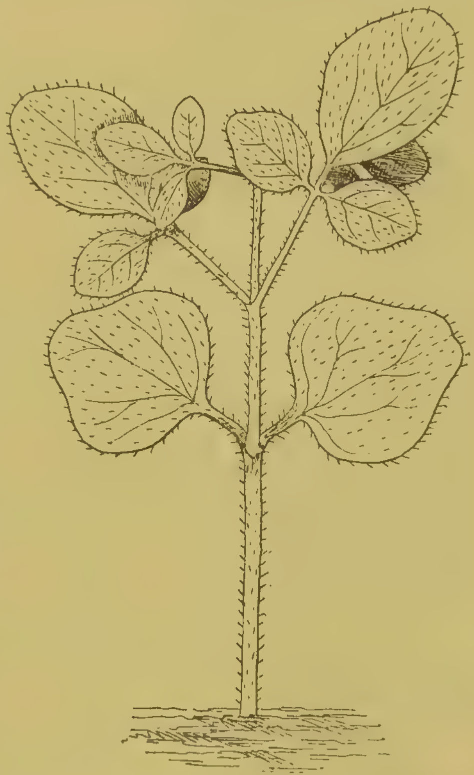
Fig. 570.—*Pithecoctenium muricatum*, × 2.

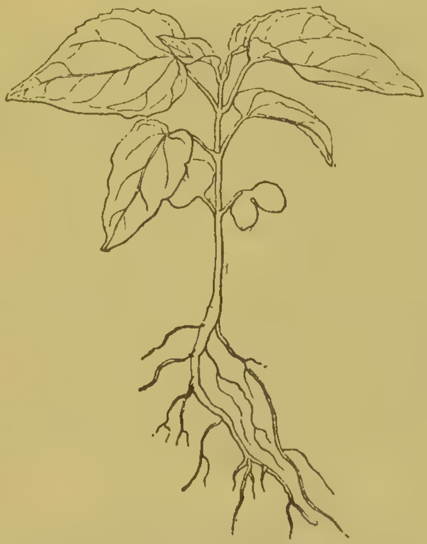
Fig. 571.—*Catalpa Kæmpferi*.
Half nat. size.

First pair ovate, obtuse, unequal at the base, with one or two obsolete teeth on each side.

Second pair ovate-cordate, obtuse, submucronate, five-nerved, and shallowly dentate in the lower half.

Third pair ovate, cordate, acuminate, five-nerved in the lower half and dentate along two-thirds of their length.

Ultimate leaves large, cordate, entire or triangular or shortly trifid above the middle, five-nerved at the base; lateral lobes small, triangular, obtuse or acuminate; middle lobe short, broad, triangular, suddenly acuminate.

Catalpa syringæfolia, *Bunge, var.* speciosa.

Hypocotyl as in C. Kæmpferi; 3 cm. above the soil.

Cotyledons very similar to those of C. Kæmpferi but larger, trinerved at the base with the middle one terminating in the notch; lobes broadly obovate, 2 cm. long, 3·15 cm. from the tip of one to the tip of the other.

Stem sparingly pubescent and covered with lenticels, green, and purplish towards the base; 1st internode 2·65 cm. long; 2nd 2·7 cm.; 3rd 2·4 cm.

Leaves similar to those of C. Kæmpferi, opposite, decussate.

First pair of leaves subcordate, acuminate, distantly and minutely dentate.

Second and third pairs cordate, acuminate, entire.

Fourth pair cordate, acuminate, distantly dentate on the lower half.

Catalpa bignonioides, *Walt.*

Hypocotyl as in C. Kæmpferi.

Cotyledons deeply bipartite nearly to the base of the lamina, glabrous except the basal part and both surfaces of the petiole; real length of the lamina about 3 mm.; lateral lobes 1·3–1·5 cm. long, 1–1·15 cm. wide; width across both lateral lobes 2·4–2·6 cm.; midrib ending below the sinus and giving off from each side two lateral nerves which run into the lobes and, uniting some distance below their apex, give off numerous smaller anastomosing branches; petiole cuneate, tapering to the base, grooved on the upper surface by the upturning of the edges, convex on the back, strongly trinerved, finely and densely glandular-pubescent or papillose, about 5 mm. long.

Leaves opposite, decussate, and ternately verticillate, unequal, alternately incurvinerved and reticulate, papillosely glandular on the nerves on both surfaces and margin, deep green above, paler beneath; petioles subterete and shallowly grooved, or terete and obsoletely channelled above, glandularly papillose especially on the upper surface.

First, second and third pairs cordate, acute or subacute, unequal, entire.

Tecoma stans, *Juss.*

Hypocotyl erect, terete, pubescent with short, spreading or deflexed hairs, green, about 1·6 cm. above the soil.

Cotyledons deeply bi-fid or -partite with rotund-obovate, divaricate lobes, trinerved with the middle nerve ending in the sinus, glabrous, pubescent at the margin, green above and covered with minute grey dots, very pale beneath, tapering into the petiole; lamina 1·2 cm. long, 2·2 cm. from the tip of one lobe to that of the other; petiole grooved above, tapering to the base.

Stem erect, terete, green, pubescent; 1st internode 3·2 cm. long; 2nd 1·1 cm.; 3rd 7 mm.; 4th 8 mm.

Leaves simple, ultimately compound, cauline, opposite, decussate, exstipulate, petiolate, glabrous, shining, penninerved with alternate, ascending nerves, subincurved towards their apex; petioles semi-terete, deeply channelled above, sparingly pubescent.

First and second pairs lanceolate, incise-serrate.

Third and fourth pairs lanceolate, acuminate, cuneate at the base, incise-serrate.

Tecoma Manglesii, ? *Hort.*

Hypocotyl very short.

Cotyledons small, deeply bi-lobed or -partite; lobes oblate, overlapping without any discernible venation, minutely pubescent on the upper side; lamina ·75–1·25 mm. to the base of the sinus; lobes about 4·5 mm. long and 6 mm. wide; petiole about ·5 mm. long.

Stem erect at first, rather acutely quadangular, pale green and straight for the first five nodes, above which it commences to twist and then to twine, glabrous except at the nodes where the bases of the petioles are connected by a ridge furnished with hairs, purple above the fifth node; 1st internode 1·75 mm. long; 2nd 3·25 mm.; 3rd 1·1 cm.; 4th 1·45 cm.; 5th 2·15 cm.; 6th 3·25 cm.; 7th 5·15 cm.

Leaves compound, imparipinnate (first pair simple), cauline, opposite, exstipulate with a horizontal rim or plate connecting the bases of the petioles, scaberulous on both surfaces, deep green and shining above, paler beneath or glaucous; rachis of leaf narrowly winged; leaflets articulated with the rachis, alternately penninerved with the nerves incurved at the top and uniting one with another forming a few large reticulations; petiole semiterete, rather deeply grooved above, or very narrowly winged at the edges, thinly pubescent.

First pair of leaves small, ovate, obtuse, simple, entire.

Second pair digitately trifoliolate; lateral leaflets obovate, slightly crenate or entire; terminal one elliptic, crenate-dentate, tapered to the base.

Third pair pinnately trifoliolate; lateral leaflets cuneate, coarsely and obtusely dentate; terminal one rhomboid, shallowly lobulate or coarsely dentate.

Fourth pair pinnately five-foliolate; lateral leaflets cuneate, the terminal one elliptic, all coarsely dentate, undulate at the margin.

Fifth pair similar but larger.

Sixth and seventh pairs seven-foliolate; lateral leaflets rotund, cuneate, flat, irregularly crenate or obtusely dentate.

Eighth and ninth pairs pinnately nine-foliolate; lateral leaflets cuneate, crenate, often almost entire; terminal one lanceolate-elliptic, obtuse.

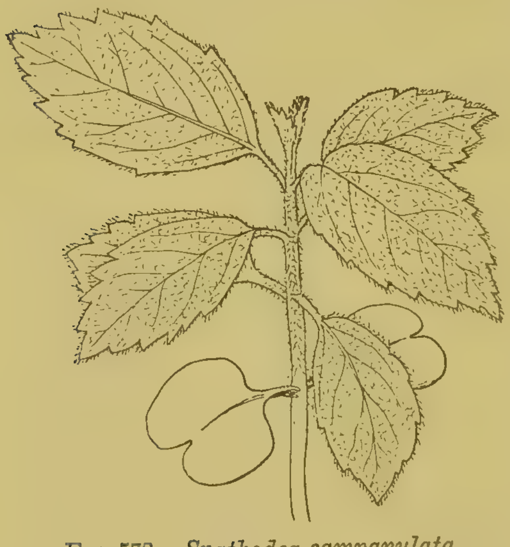

FIG. 572.—*Spathodea campanulata.* Nat. size.

Spathodea campanulata, *Beauv.* (fig. 572).

Hypocotyl 1–2 cm. long, 2–3 mm. thick, woody, terete, glabrous, greyish.

Cotyledons nearly equal, 1·5 cm. long including the short petiole, 1·25 cm. wide, broadly oblate, shortly bifid with the apex of the two short lobes rounded, glabrous, light green, rather caducous; midrib obscure.

Stem with internodes 5 mm. long, 2 mm. thick, terete, pubescent, green with white bands.

Leaves simple in the early stage of the seedling, ultimately compound, pinnate, cauline, opposite, exstipulate, petiolate, alternately and ascendingly penninerved, hairy; early leaves simple and serrate; leaflets of the leaves of adult plants said to be entire.

First pair elliptic, irregularly serrated, with sunk midrib, penninerved, shortly petiolate, hispid or slightly scabrous, membranous, not very persistent.

Second, third and fourth pairs inclusive or a smaller number, similar but larger.

Fifth pair with one or two small leaflets at base of blade quite or partly detached.

Sixth pair pinnate.

Incarvillea Olgæ, *Regel* (fig. 573).

Hypocotyl erect, terete, glabrous, pale green, 1–1·7 cm. long.

Cotyledons triangular, obtuse, shallowly emarginate, truncate at the base, obscurely and alternately incurvinerved, deep opaque green, petiolate; lamina 5–6 mm. long, 4–7 mm. wide; petiole slightly channelled above, glabrous, almost biconvex, connate at the base, 6–10 mm. long.

Stem herbaceous, erect, terete, glabrous, pale green or stained with red; 1st internode 2·75 mm. long; 2nd 4 mm.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately penninerved, glabrous, deep green above, paler beneath, shining on both surfaces; petioles semiterete, glabrous, channelled above, subconnate at the base.

First pair ovate, obtuse, minutely cuspidate, with one to two small serratures on each side, about the middle.

Second pair similar, but more acutely cuspidate.

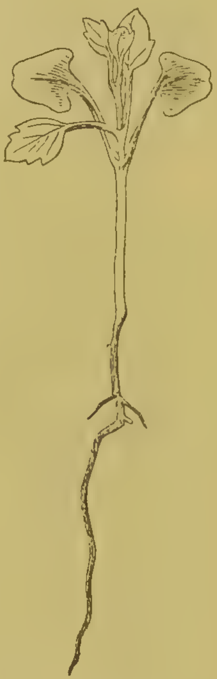

FIG. 573.
Incarvillea Olgæ.
Nat. size.

Incarvillea compacta, *Maxim.*

Hypocotyl short, not appearing above the soil.

Cotyledons almost reniform, broadly cordate at the base, emarginate, obtuse, with long petioles, fleshy, dark green, glabrous, indistinctly trinerved.

First leaves simple, radical, alternate, minutely emarginate, cordate at the base, oblong, unsymmetrical, one side of the leaf extending farther down the petiole than the other, exstipulate, with very long petioles, bright green on the upper side, subglaucous beneath, glabrous, pinnatinerved.

Eccremocarpus scaber, *Ruiz et Pav.* (fig. 574).

Primary root slender, fibrous, giving off lateral branches.

Hypocotyl erect, terete, glandular-pubescent, almost colourless, 1–1·3 cm. long.

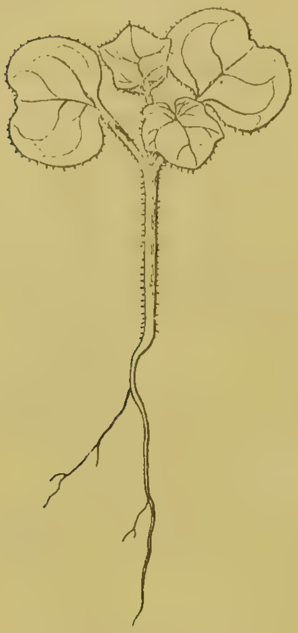

Fig. 574.
Eccremocarpus scaber, × 2.

Cotyledons subreniform, deeply and broadly emarginate with a mucro in the sinus, two alternate incurved nerves on each side, thinly glandular-hairy on both surfaces and glandular-ciliate; lamina 4–5 mm. long, 6–7·5 mm. wide; petiole semiterete, decurrent on the hypocotyl or subconnate, glandular-pubescent, channelled above, 3–4·5 mm. long.

Stem herbaceous, slender, erect, ultimately climbing; 1st internode ·5–1 mm. long.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately penninerved, glandular-hairy on both surfaces, bright green; petioles semiterete, channelled above, somewhat dilated at the base, glandular-hairy.

First pair rotund, obtuse, five- to seven-angled or -toothed, with a strong nerve entering each tooth, which is tipped with a mucro.

Ultimate leaves bipinnatisect and terminating in a simple or branched cirrhus, by which the plant is enabled to climb.

Crescentia Cujete, *L.* (fig. 575).

Hypocotyl erect, terete, minutely and finely pubescent, pale green, 1·5–1·8 cm. above the soil.

Cotyledons broadly ovate-oblong, very obtuse, rather deeply and narrowly emarginate, appearing subcordate from a sudden curvature at the base of the lamina, petiolate, trinerved with a few short alternate nerves directed upwards, light green above, paler beneath, glabrous; lamina 1·2–1·35 cm. long, 1·15 cm. wide; petiole with a shallow furrow on each side of a median ridge, minutely pubescent, pale green, connate at the base, ascending and bearing the lamina horizontally, 4 mm. long.

Stem erect, subterete in a very early stage with a shallow furrow on two sides, very shortly pubescent, pale green, ultimately woody, with a pale-coloured, rough and knotty bark; 1st internode 8–10 mm. long.

Leaves simple, cauline, entire, fascicled or opposite on the seedling, exstipulate, shortly petiolate or almost sessile, alternately incurvinerved, deep green above, paler beneath, with the nerves sunk on both surfaces, obscurely reticulate, glabrous; petiole very short or almost absent, grooved on the upper side by the decurrent margin of the leaf.

First pair of leaves obovate-elliptic, tapered to the base, obtuse and tipped with a small mucro.

Ultimate leaves irregularly grouped or fascicled, lanceolate, oblong-lanceolate, linear-lanceolate or elliptic-lanceolate, very variable in length, generally much tapered to both ends, obtuse, alternately penninerved, with the nerves incurved and giving off recurved branches, forming an arch, and in all cases uniting with one another, and anastomosing some distance within the margin, much punctate beneath, decurrent almost to the very base, reducing the petiole to its much thickened base.

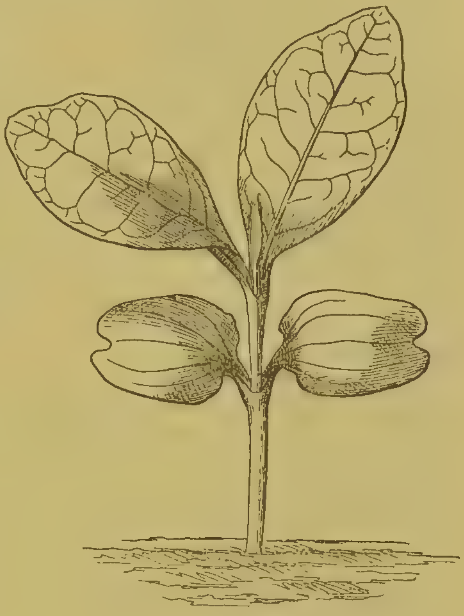

FIG. 575.—*Crescentia Cujete.* Nat. size.

PEDALINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1054.

Fruit and Seed.—The ovary is superior, sometimes one-celled with two parietal placentas each divided into two lamellæ projecting into the cavity; sometimes two- rarely three- or four-celled with the cells undivided, or in other cases subdivided by spurious septa or ingrowths from the wall. The ovules are solitary in each cell or numerous and superposed in a single series, horizontal, ascending, pendulous, or erect from the base and anatropous. The fruit is capsular, nutlike, or more rarely subdrupaceous, with a fleshy endocarp. The endocarp as well as the placentas or even the whole fruit becomes very much hardened at maturity, and is often also prickly, dehiscing loculicidally by two valves at the apex or almost throughout its length or it is indehiscent. Internally it is two-celled or divided into locelli twice as numerous as the carpels. The seeds vary in number as the ovules, arise from the inner angles of the cells, and are obovate, oblong, or orbicular and often compressed. The testa is smooth or depressed into little areolæ, and sometimes though rarely it is expanded into a hyaline wing. As endosperm is wanting, the embryo conforms to the seed and has flat or plano-convex somewhat fleshy cotyledons, with a short straight radicle close to the hilum.

The seeds of Sesamothamnus are compressed or flattened and winged ; in some species of Sesamum they are also somewhat compressed and narrowly two-winged.

The ovary of Martynia proboscidea consists of two carpels, and is one-celled with numerous ovules superposed on two parietal placentas. The fruit is somewhat baccate, but ultimately dehiscent. The seed is obovate, compressed and rugose, with the external coat very much thickened and hardened. The inner coat is membranous, hugs the embryo pretty closely, and is shorter, as a rule, than the testa when the seed is dry, leaving an empty space at the end next the hilum. The embryo is straight with obovate, three- or faintly five-nerved cotyledons slightly auricled around the radicle, and shallowly emarginate owing to a thickening at the chalaza.

Seedlings.—The seedlings of Martynia are glandular-hairy all over and notable for their great size, particularly for the length of the hypocotyl. The cotyledons of Martynia fragrans are roundly oblong, broadly and shallowly emarginate, and auricled at the base, with several ascending branching nerves on each side of the midrib. The first pair of leaves are oblong-oval, much smaller than the cotyledons, and like them densely and coarsely glandular-hairy. The cotyledons of M. proboscidea are comparatively narrower than the last, and oblong, deeply auricled at the base, and five-nerved. They fall away rather early. The leaves are opposite and densely glandular-hairy. The first pair are oblong-cordate and five-nerved. The second pair are roundly cordate and five-nerved, while the third pair are similar but very much larger and five- to seven-nerved.

Martynia proboscidea, *Gloxin.*

Pistil surrounded at the base by a disc; ovary one-celled, many-ovuled; ovules pendulous, anatropous; radicle superior.

Fruit a subdrupaceous or rather sub-baccate capsule, one-celled, with two broad or lamellate parietal placentas, many-seeded, dehiscing loculicidally. It terminates in two long curved horns, which attach themselves to animals and so disseminate the plant. I have already figured it in 'Flowers, Fruits and Leaves' (fig. 51).

Seed obovate, dorso-ventrally compressed, rugose and raised into numerous short, blunt projections round the margins, but especially of the upper half; testa thick, cortical, rough, black; tegmen thin, almost membranous, white; hilum close to the apex on the ventral aspect, forming an open cavity when dry; micropyle basal and contiguous to the hilum; chalaza more or less prominent and thickened externally, and also forming a more or less evident thickening on the inner coat, most evident when moist and discoloured.

Endosperm absent.

Embryo straight, large, obovoid, dorso-ventrally compressed, conforming closely to the tegmen, colourless; cotyledons obovate, plano-convex, emarginate at the chalaza, three- or indistinctly five-nerved from the base upwards, thick and fleshy, auricled at the base to fill the seed while accommodating the radicle; radicle very stout, blunt, turbinate, short and only slightly protruded beyond the cotyledons.

Seedling.

Primary root tapering downwards, with numerous lateral rootlets immediately at the base of the hypocotyl, brownish-orange, annual.

Hypocotyl erect, terete, densely glandular-hairy or pubescent, pale green, stout, fleshy, 6 cm. long.

Cotyledons large, oblong, obtuse, cordate or auricled at the base, coarsely hairy on both surfaces, petiolate, dull green; lamina 2 cm. long, 1·3 cm. wide; petiole channelled above, about 2 cm. long.

Stem herbaceous, annual, stout or fleshy, erect, terete, pale green, densely glandular-hairy; 1st internode 2·35 cm. long; 2nd 1·3 cm.; 3rd 1 cm.; 4th 9 mm.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate, five- to seven-nerved with ascending, slightly incurved nerves, reticulate, densely glandular-hairy all over, viscid, odoriferous, dull green;

petioles subterete, narrowly channelled above, stout, tapering towards the apex, densely glandular-hairy, pale green.

First pair oblong-cordate, obtuse, entire, slightly wavy at the margin, five-nerved.

Second pair rotund-cordate, obtuse, entire, five-nerved; three of the nerves spring directly from the apex of the petiole and are naked, that is without parenchyma on the sides at the base.

Third pair rotund-cordate, obtuse, five- to seven-nerved, obscurely and distantly dentate at the apex of the principal nerves and veins; three principal nerves as in the second pair.

Fourth pair with closed or overlapping auricles at the base, and more decidedly dentate at the apex, otherwise like the third.

Martynia fragrans, *Lindl.*

Hypocotyl as in M. proboscidea, densely glandular-hairy, 7–10·5 cm. long.

Cotyledons somewhat fleshy, broadly oblong or subrotund, emarginate, auricled at the base with a long channelled petiole, covered with glandular hairs, pinnatinerved as in the leaves.

Stem as in M. proboscidea; 1st internode 1–1·2 cm. long.

First leaves opposite, oval-oblong, obtuse, shortly petiolate, ciliate, covered with glandular hairs, light green, pinnatinerved.

ACANTHACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1060.

Fruit and Seed.—The ovary, consisting of two carpels, is superior, two-celled, and undivided. The ovules are collateral in pairs in each cell of Thunbergia; in the tribe Nelsonieæ they are numerous and superposed in a double series; and in all other tribes they vary from two to many, but seldom exceed eight, and are arranged in a single series or alternately one above the other. In all cases they are anatropous or shortly amphitropous. The fruit is a capsule (except in Mendoncea where it is one-seeded and drupaceous), globose, oblong, oblong-linear, terete or compressed in various ways, equal from the base upwards, or contracted at the base forming a solid, seedless stalk. It dehisces loculicidally from the apex to the base, including the solid, seedless portion, and often bursts elastically with some force, the valves carrying with them the seed-bearing half-placentas. The seeds vary in number as the ovules, but are frequently fewer by abortion. In Thunbergia and in the tribe Nelsonieæ they are globose or orbicular and dorsally compressed with a ventral hilum. In other tribes they are laterally compressed and ascending, with the hilum basal and marginal. The funicle is hardened and incurved, forming the hook-like process (retinaculum) upon which the seed is borne; sometimes this hook is produced beyond the point of attachment to the seed. The testa is membranous or thickened, often variously corrugated or raised into little points; it is sometimes smooth or covered with mucilage which when dry forms a covering resembling adpressed hairs. Endosperm is wanting except in the species belonging to the tribe Nelsonieæ. In other groups the embryo occupies the whole of the interior of the seed, and conforms to its cavity. The cotyledons are orbicular, flat or plano-convex, and cordate at the base. The radicle is short and straight or bent obliquely to the axis of the cotyledons, and occupies the basal notch of the latter.

The ovule, embryo and seed are often variously abnormal in the tribes Thunbergieæ, Nelsonieæ and the subtribe Andrographideæ. The ovules for instance of Thunbergia fragrans are amphitropous; the seeds are orbicular, dorsally compressed and concave on the ventral face where the hilum is situated. The embryo occupies the whole interior of the seed and is concave on the ventral aspect in conformity with the seed. The cotyledon on the ventral aspect has its edges recurved, partly covering the outer one on the dorsal aspect.

About four other types have come under my observation. The ovules of Acanthus spinosus are amphitropous or semi-anatropous and twin in each cell. The embryo is transversely oval and slightly emarginate in a young state, gradually becoming more orbicular as it reaches maturity, and the radicle is wholly included between the close-fitting auricles of the cotyledons. This is better seen in the longitudinal section of the seed of A. longifolius (fig. 579) which has transversely oval cotyledons somewhat indented near the chalaza, and deeply auricled around the radicle. They are plano-convex, with the radicle nearly on the opposite side of the seed from the hilum.

A very common type is represented by Strobilanthes callosus which has orbicular nearly flat five-nerved and reticulated cotyledons, deeply and unequally auricled at the base, nearly concealing the radicle. The latter is terete and in its lower half curved round one edge of the cotyledons. The seed is slightly and obliquely indented at its insertion on the retinaculum. The cotyledons are shortly petiolate while yet in the seed; but the strong auricles spread out and partly disappear after germination.

Ruellia longifolia (fig. 577) differs from the last in having a straight radicle and equal or nearly equal auricles. The flat orbicular seed is not indented at the hilum, but is slightly prominent at its insertion on the retinaculum. It is also papillosely hairy round the margin, with hairs of a mucilaginous nature which swell in water. The seed of Eranthemum leuconeurum (fig. 580) is rotund-ovate, flattened and unsymmetrical, with a slight indentation above the base on one side. There is a little tubercle or elevation at the hilum, and the testa is produced into a little sac at the base to accommodate the radicle, which is not surrounded by the cotyledons. The latter are minutely auricled at the base, trinerved and reticulate. This peculiar conformation of the seed gives the cotyledons a cuneate outline which becomes much more apparent after germination. In the seedlings examined they were much more symmetrical than while yet in the seed, and slightly emarginate.

Seedlings.—The cotyledons in this Order are mostly if not always large in comparison with the size of the seed and foliaceous. Although always of simple types, they are exceedingly varied in form.

A somewhat frequent form, represented by Dipteracanthus micranthus, has suborbicular emarginate trinerved cotyledons shallowly but generally unequally auricled at the base. In this instance the hypocotyl is very short; and the first pair of leaves are oval. The cotyledons of Ruellia barbadensis are five-nerved but otherwise similar. Those of Hygrophila longifolia are almost truncate at the base. The hypocotyl is elongated; and the first pair of leaves are lanceolate. Many others conform pretty closely to this type. A curious dimorphism of the leaves may be noted in Asystasia coromandeliana. The first two pairs of leaves are ovate, followed by others which become broader and shorter until they are almost rotund on the upper part of the plant. The leaves of the first pair produced on the primary branches are small, generally very unequal in size and obovate, emarginate, or broadly ovate and cuspidate, or one of the two may be small, orbicular and entire. Succeeding ones gradually assume the normal form.

Another type where the cotyledons are very much shortened and almost reniform is represented by Blechum Brownei. In this species they are emarginate, truncate at the base, but cuneate at their attachment to the petiole and five-nerved. The cotyledons of Strobilanthes gossypinus differ slightly in being entire, trinerved, larger and almost truncate at the base. The primary internodes are very short, and the two first pairs of leaves are broadly ovate, densely hairy, and overlap one another in a decussate manner. Dipteracanthus prostratus agrees with the last, but the cotyledons are five-nerved. The cotyledons of Strobilanthes callosus correspond more closely to the type; they are deeply and widely cordate at the base, foliaceous, and measure 2·5–2·9 cm. long, by 4·2–4·4 cm. wide. The hypocotyl is of considerable length, and so are the primary internodes of the stem. This also applies to Phaylopsis parviflora (fig. 578) although in a less degree. The cotyledons have a rather longer, trinerved lamina than in Blechum Brownei; and the primary leaves are ovate with finely incurved alternate nerves.

Peristrophe speciosa (fig. 583) represents a third type having obliquely obovate, cuneate, emarginate, trinerved cotyledons. The first pair of leaves are ovate with a well-marked, incurved, penninerved venation. The cotyledons of P. bicalyculata are similar but smaller and unsymmetrical. The first pair of leaves are lanceolate. In Eranthemum leuconeurum (fig. 581) the cotyledons are still smaller than the last, very slightly emarginate, and symmetrical or nearly so. The first two pairs of leaves are very broadly oval. The cotyledons of Thunbergia alata (fig. 576) are rotund-oblong, entire, cuneate at the base and trinerved with long petioles, as the hypocotyl scarcely appears above ground. The first two pairs of leaves are triangular-hastate, slightly and irregularly dentate, five-nerved and suddenly decurrent upon the long petioles, forming narrow wings to them. Asystasia coromandeliana (fig. 582) differs in having unsymmetrically orbicular slightly emarginate cotyledons, suddenly tapering into their petioles. The leaves of first pair are ovate with an incurved anastomosing venation similar to that of Peristrophe speciosa. A very remarkable type is met with in Thunbergia reticulata; the cotyledons are unequal, orbicular, trinerved, cordate at the base and minutely denticulate at the margin, particularly the larger one which has a peculiar elevation in the centre. Another case of unsymmetrical cotyledons is met with in Dicliptera resupinata where they are oblong, emarginate, trinerved and rather deeply sinuated on one side or almost falcate. Those of Justicia bracteata are obovate-oblong, emarginate, trinerved, and somewhat reticulated. Another curious development in the same direction is met with in Schwabea ciliaris, which has oblong, emarginate, one-nerved, fleshy, shortly petiolate cotyledons. The hypocotyl is greatly elongated and finely hairy, as is the first internode of the stem. The first three pairs of leaves are lanceolate and penninerved with ascending nerves.

Thunbergia alata, *Boj.* (fig. 576).

Hypocotyl short, terete, pale green, densely pubescent.

Cotyledons large, foliaceous, petiolate, deep green above, paler beneath, densely pubescent on both surfaces ; lamina rotund-oblong, trinerved, subcuneate at the base, 2·6 cm. long, 2·5 cm. wide ; petiole channelled above, pubescent, 2·7 cm. long.

Stem herbaceous, erect, ultimately twining, terete, thickened at the nodes, densely pubescent, green, purple at the nodes ; 1st internode 1·7 cm. long ; 2nd 6·5 cm. ; 3rd 7·2 cm. ; 4th 17 cm. ; 5th 15 cm.

Leaves simple, cauline, opposite, exstipulate, petiolate, softly and densely pubescent on both sides, ultimately rough and scabrous above, and deep green, paler beneath ; petioles convex on both surfaces, winged nearly to the base, pubescent, ultimately scabrous like the leaves.

First pair triangular-ovate, obtuse, truncate at the base and subhastate, irregularly dentate, five-nerved.

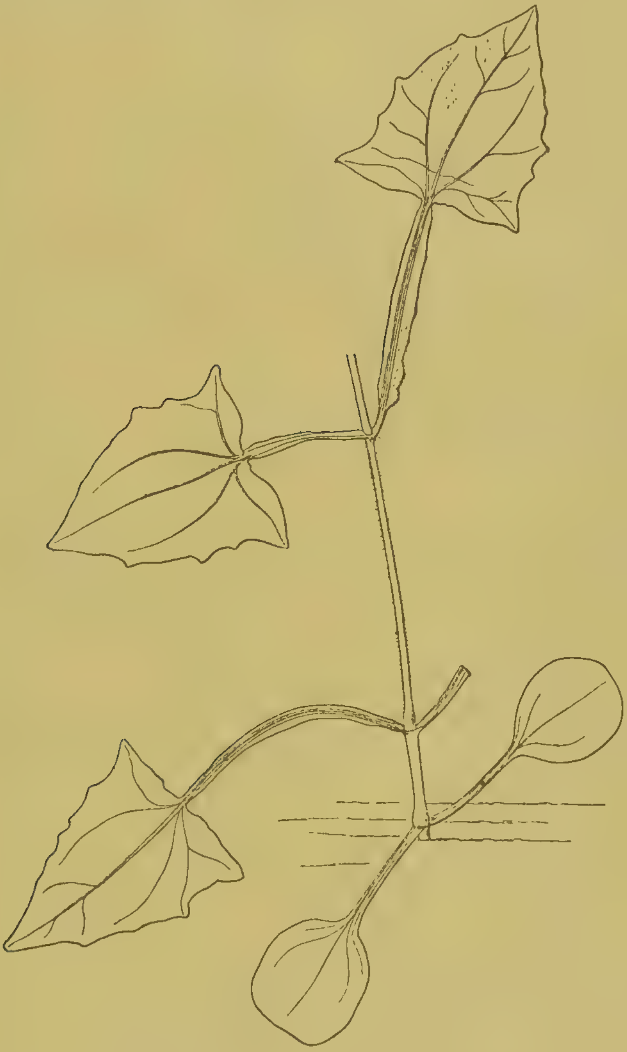

FIG. 576.—*Thunbergia alata.* Half nat. size.

Second and third pairs triangular-hastate, subcordate at the base, irregularly dentate, five-nerved.

Fourth and fifth pairs triangular-cordate, subhastate, slightly dentate or subentire, five-nerved.

Thunbergia reticulata, *Hochst.*

Hypocotyl erect, terete, pubescent, 3–4 cm. long, green, with a reddish tinge.

Cotyledons simple, unequal, orbicular, obtuse, slightly emarginate, cordate at the base, the larger one slightly denticulate, the smaller one nearly or quite entire ; the larger has also a raised portion in the centre caused probably by the funicle, which is central, petiolate, pubescent on the upper side, glabrous beneath ; midrib with numerous lateral veinlets.

Stem erect, herbaceous in the seedling stage.

First leaves ovate, acute, simple, entire, opposite, cauline, pubescent or hairy, light green, reticulate.

The seeds are dorsally compressed ; the cotyledons lying with their faces towards the hilum, which is very conspicuous, causing a deep indentation in the cotyledon, the one which is nearest the hilum being considerably thicker than the other, almost twice the thickness ; the seed is exalbuminous.

Hygrophila longifolia, *Nees.*

Hypocotyl erect, terete, with a few minute hairs, about 2 cm. long, tinged with red.

Cotyledons large, broadly oblong or almost triangular-rotund, obtuse, minutely emarginate, petiolate, glabrous except a few hairs on the petioles, dull green, alternately pinnatinerved as in the leaves, but more indistinctly.

Primary internodes of stem undeveloped.

First leaves simple, entire, radical, opposite, lanceolate, obtuse, ciliate, otherwise glabrous, petiolate, exstipulate, light green, distinctly pinnatinerved.

Ruellia longifolia, *T. Anders.* (fig. 577).

Ovary stipitate, two-celled, many-ovuled (about six to eight in a cell) ; ovules erect or vertical, anatropous ; radicle inferior.

Fruit a capsule, oblong, stipitate, dorsally compressed with a lateral groove and a slightly conspicuous dorsal midrib, tipped with the shortly conical persistent base of the style, glandular-pubescent, obtusely subquadrangular, dehiscing loculicidally.

Seed orbicular, laterally much compressed, lying in the hooked processes of the placenta which are given off right and left alternately, minutely reticulate or wavy on the flattened faces and papillose at the margin ; hilum and micropyle contiguous, basal, inferior.

Endosperm in the full grown seed just before maturity, forming a thin, white layer, entirely surrounding the embryo

Embryo straight, conforming to the interior of the seed, large, colourless ; cotyledons orbicular, flat, deeply auricled at the base, three- or five-nerved, with the lateral nerves giving off two very strong branches from their posterior side at the base into the auricles which are large, deltoid, obtuse and slightly unequal, lying in the broad plane of the seed, and conforming in outline to its interior with their basal edges to the hooked process of the placenta, and their backs to the axis; radicle oblong-fusiform, tapered to an obtuse point and projecting about one-third of its length or less beyond the auricles, and having its tip close to the hilum and micropyle.

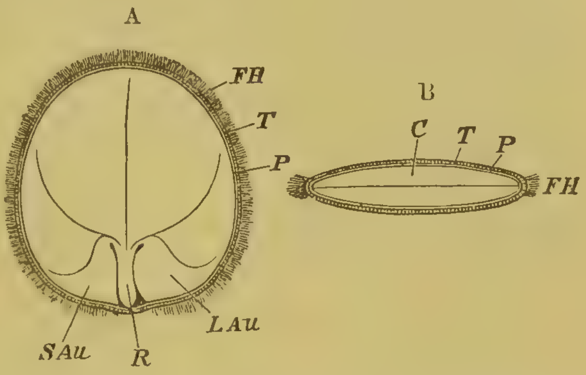

Fig. 577.—*Ruellia longifolia*, × 10. A, longitudinal section of seed: *SAu*, smaller auricle; *R*, radicle; *LAu*, larger auricle; *P*, endosperm; *T*, testa; *FH*, fringe of hairs. B, transverse section of seed: *C*, cotyledon; *T*, testa; *P*, endosperm; *FH*, fringe of hairs.

Ruellia barbadensis, *Benth. et Hook.*

Hypocotyl erect, terete, glabrous, 1·0–1·5 cm. long, light green or colourless.

Cotyledons suborbicular or almost reniform, obtuse, emarginate, petiolate, glabrous, light green, five-nerved, almost truncate at the base; petiole rather long, channelled on the upper side.

Stem erect, terete, pubescent, herbaceous; 1st internode 1·5–2 mm. long.

Dipteracanthus micranthus, *Engelm. et Gray.*

Hypocotyl erect, terete, pubescent, 3–4 mm. long, light green or colourless.

Cotyledons broadly oblong, obtuse or triangular, entire or minutely emarginate, cordate at the base, petiolate with rather long petioles, glabrous except on the petioles, dark green, pinnatinerved, the lower nerves much longer than the others.

Stem erect, terete, herbaceous, ultimately woody, pubescent; 1st internode 4–5 mm. long.

First leaves simple, entire, cauline, opposite, exstipulate, oblong-oval, obtuse, shortly petiolate, ciliate, pubescent, light green, alternately pinnatinerved.

Dipteracanthus prostratus, *Nees.*

Hypocotyl short, scarcely appearing above the soil.

Cotyledons oblate or almost reniform, entire, slightly auricled at the base, glabrous, green, five-nerved at the base; petiole long, flat, hairy, channelled above.

Stem as in last species, but covered with long, dense, white hairs; 1st internode 2–2·5 cm. long; 2nd 3–4 cm.; 3rd about 2 cm.

First leaves opposite, decussate, broadly lanceolate or elliptic, cuneate at the base, obtuse, shallowly crenate, ciliate, hairy; petioles stout, hairy, almost flat, scarcely channelled above.

Phaylopsis parviflora, *Willd.* (fig. 578).

Hypocotyl erect, terete, pubescent with decurved hairs, purplish, about 1·6 cm. above the soil.

Cotyledons semiorbicular, emarginate, truncate at the base or tapering slightly into the petiole; lamina glabrous, 7 mm. long 1 cm. wide; petiole channelled above, pubescent, 7·5 mm. long.

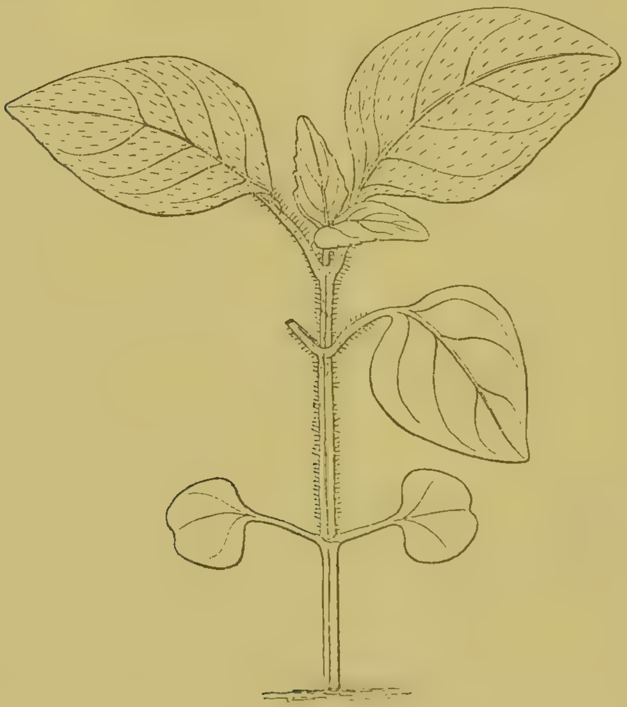

FIG. 578.—*Phaylopsis parviflora.* Nat. size.

Stem herbaceous, erect, quadrangular, somewhat thickened at the nodes, pubescent with short decurved hairs, and somewhat bearded at the young nodes, purplish; 1st internode 2 cm. long; 2nd 1 cm. or more when fully developed.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, pubescent on both surfaces, deep green above, very pale or subglaucous beneath (at least when young); petioles convex on both surfaces, densely pubescent with upcurved hairs which are arranged in lines on the upper surface, slightly grooved on each side.

Hairs of leaves glandular at the base (at least when young).

First and second pairs broadly ovate, obtuse, entire, subcuneate at the base.

Third pair ovate, obtuse, shallowly dentate.

Blechum Brownei, *Juss.*

Hypocotyl erect, terete, hairy, 2–2·4 cm. long, light green or colourless.

Cotyledons oblate, obtuse, almost truncate at the base, entire or minutely emarginate, petiolate, slightly hairy, light green, five-nerved; petiole rather long, channelled on the upper face.

Stem erect, square, herbaceous, ultimately woody, pubescent; 1st internode 6–15 mm. long; 2nd shorter.

First leaves simple, entire, cauline, opposite, decussate, broadly ovate or oval, obtuse, exstipulate, petiolate, hairy and green above, minutely hairy and subglaucous-green beneath, pinnatinerved; petioles short, hairy, furrowed on the upper side.

Strobilanthes callosus, *Nees.*

Ovary two-celled, with one ovule in each cell; ovule erect, anatropous, seated on the middle of a twice curved process of the placenta (retinaculum).

Fruit a capsule, elliptic, dorsally compressed, glabrous, pale brown, shining, somewhat woody, dehiscing loculicidally and septicidally, two-celled with one seed in each cell.

Seed large, flat, laterally compressed, suborbicular, obliquely cut away at the base on one side of the hilum, where it rests on the free apex of the retinaculum, 9 mm. long, 8 mm. wide, 1·5–2·25 mm. thick in the middle, becoming thinner towards the edges, exalbuminous; testa thin, membranous, covered with whitish, adpressed mucilaginous hairs, except a small, ovate, glabrous space on each side at the base.

Embryo very large, and occupying the whole of the seed, except a small portion at the obliquely cut base which is occupied with cortical matter, colourless; cotyledons large, suborbicular, deeply notched at the base, plano-convex with a conspicuous, ramifying and forked venation, the larger lateral veins being ascending and incurved and the basal ones recurved to support the large auricles, very shortly petiolate in the seed; radicle terete, straight in the upper portion where it lies between the auricles of the cotyledons, and in the lower portion curved to that side next the base of the retinaculum, to the middle of which it is attached.

Seedling.

Hypocotyl erect, terete, striate or furrowed, covered with lines of white hairs, 2–2·5 cm. above the soil.

Cotyledons reniform, very large, deeply and widely cordate at the base, glabrous except the petiole and base, deep green above, whitish beneath; lamina 2·5–2·9 cm. long, 4·2–4·4 cm. wide; petiole subterete or slightly flattened at the base on the upper side, hairy, 3·5–3·8 cm. long.

Stem erect, terete, slightly channelled, hairy; 1st internode 5–6 cm. long; 2nd 6–8 mm.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, hairy, crenate-serrate; petioles biconvex, or with an elevated midrib above.

First and second pairs ovate, acuminate, obtuse.

Strobilanthes gossypinus, *T. Anders.*

Hypocotyl pubescent, 3–8 mm. long, reddish-green.

Cotyledons coriaceous, oblate or almost reniform, rather unequal, obtuse, slightly cordate at the base, entire, glabrous except on the petioles, dark green, trinerved.

Stem erect, terete, herbaceous, pubescent; 1st internode 3–5 mm. long; 2nd shorter.

First leaves opposite, decussate, shortly petiolate, ovate, subacute or obtuse, densely pubescent, dark green, alternately pinnatinerved.

Acanthus longifolius, *Host.* (fig. 579).

Ovary two-celled, each cell two-ovuled; ovules alternately superposed, amphitropous; radicle transverse.

Fruit a capsule, ovoid-oblong, slightly contracted or narrowed at the base, and suddenly narrowed at the tip, glabrous, shining, pale brown, two-celled, with each cell one- to two-seeded, dehiscing elastically when dry along the dorsal suture and placentas from base to apex into two pieces each of which consists of half each carpel; pericarp separating into two coriaceous layers.

Seed large, obliquely oblong or ovate, dorso-ventrally compressed, but chiefly ventrally, smooth or variously wrinkled and ridged; testa coriaceous, deep brown; tegmen thicker, paler; hilum obliquely basal; micropyle on the opposite side from the hilum and near the middle of the seed; seed 13 mm. long, 7–10 mm. broad, 5 mm. thick.

Endosperm absent in the mature seed; but previous to maturity forming a layer or cup enclosing the growing embryo, close to the hilum and at the base of the seed, fleshy.

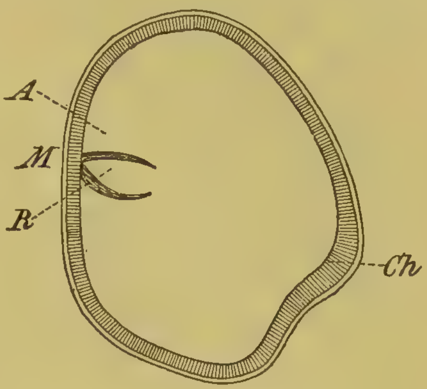

FIG. 579.—*Acanthus longifolius*, × 3. Longitudinal section of seed: *M*, micropyle; *R*, radicle; *A*, auricle of cotyledon; *Ch*, chalaza.

Embryo straight, transverse, large and ultimately occupying the whole interior of the seed; cotyledons oblate-orbicular, plano-convex, rather deeply cordate at the base with the auricles closed over the radicle, and having an oblique impression on one side near the apex caused by the attachment of the retinaculum, equal in length and breadth to the seed, closely applied face to face; radicle transverse to the seed, short, obtuse, included between the cotyledons.

Acanthus spinosus, *L.*

Ovary surrounded at the base with an annular disk, two-celled; ovules attached a little above their bases to long retinacula of which there are two in each cell pointing alternately right and left; ovules oblique, amphitropous or semianatropous, with the radicle in the growing condition, at a point in a diagonal line with the insertion on the retinaculum.

Capsule obovoid, compressed or subcompressed, antero-posteriorly tipped with the woody remains of the base of the style, or its whole length, glabrous, deep green and shining.

Seed elliptic, compressed, with a slender ridge along the dorsal and ventral flattened aspects, on the latter of which it is grooved towards the base by pressure against the retinaculum, glabrous, brown; hilum obliquely basal; testa very thick and succulent when growing.

Endosperm in the growing seed firm, transparent, succulent and watery, occupying the lower part of the seed, stretching across the interior diagonally and abutting against the embryo, gradually becoming less as the embryo develops, and finally disappearing when the seed approaches maturity.

Embryo straight in the young condition, plano-convex, colourless, fleshy; cotyledons at an early stage transversely oval, entire, gradually becoming orbicular or occasionally angled.

Eranthemum leuconeurum, *Fisch.* (fig. 580).

Ovary two-celled, each cell two-ovuled; ovules erect, anatropous; radicle inferior.

Fruit a capsule, oblong, cuspidately acute, stipitate, dorsally compressed, pubescent with incurved hairs and tipped with the persistent style, two-celled, and four-seeded or fewer by abortion, dehiscing loculicidally and elastically when mature, scattering the seeds; retinacula produced beyond the seed into subulate, acute points, and curved upwards.

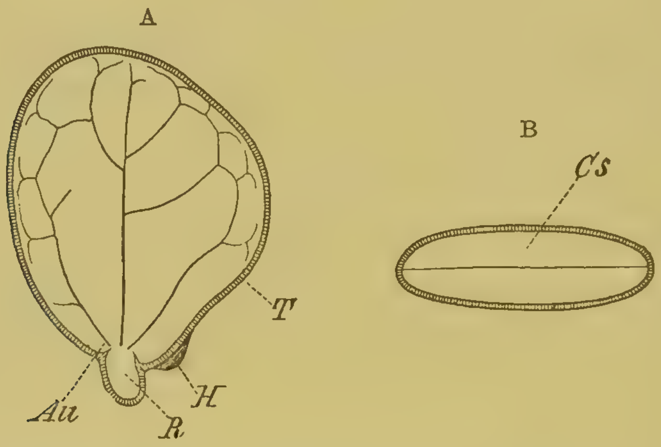

FIG. 580.—*Eranthemum leuconeurum*, × 12. A, longitudinal section of seed: *Au*, auricle; *R*, radicle; *H*, hilar process; *T*, testa. B, transverse section of seed; *Cs*, cotyledons.

Seed suborbicular, notched at the base, much compressed by the dorsal flattening of the capsule, lying on the retinaculum in the broader way of the cell, somewhat unequal at the base, with the point containing the radicle slightly longer and extending towards the side of the capsule; testa rather thin, reticulated or raised into irregular, wavy, projecting, slender ridges; raphe and chalaza inconspicuous; hilum and micropyle basal, inferior, contiguous but separated by a shallow notch; hilum surrounded on two sides by small auricles.

Endosperm in the mature seed represented by a thin white, easily separable film.

Embryo large, filling the seed to which it conforms, straight, colourless; cotyledons rotund-obovate, minutely auricled at the base, otherwise entire, plano-convex, or rather flat with rounded lower edges, lying in the broader way of the seed with their backs to the placental axis and their basal edges vertical to the retinaculum; radicle very short, oblong, obtuse, much longer than the minute auricles of the cotyledons, lying in the long basal point of the seed.

Seedling (fig. 581).

Primary root long, filiform, flexuose, colourless, with slender lateral rootlets, but soon equalled or superseded by strong adventitious roots from the base of the hypocotyl.

Hypocotyl erect or decumbent, tapering downwards, striated longitudinally with numerous, upwardly adpressed whitish hairs, pale green, 9–15 mm. long.

Cotyledons obovate, shallowly emarginate, tapering to a cuneate base, petiolate, indistinctly, irregularly, alternately incurvinerved with the nerves uniting to form an irregularly outlined submarginal one, glabrous except the petiole, deep green above, pale or glaucous beneath; lamina 8–9 mm. long

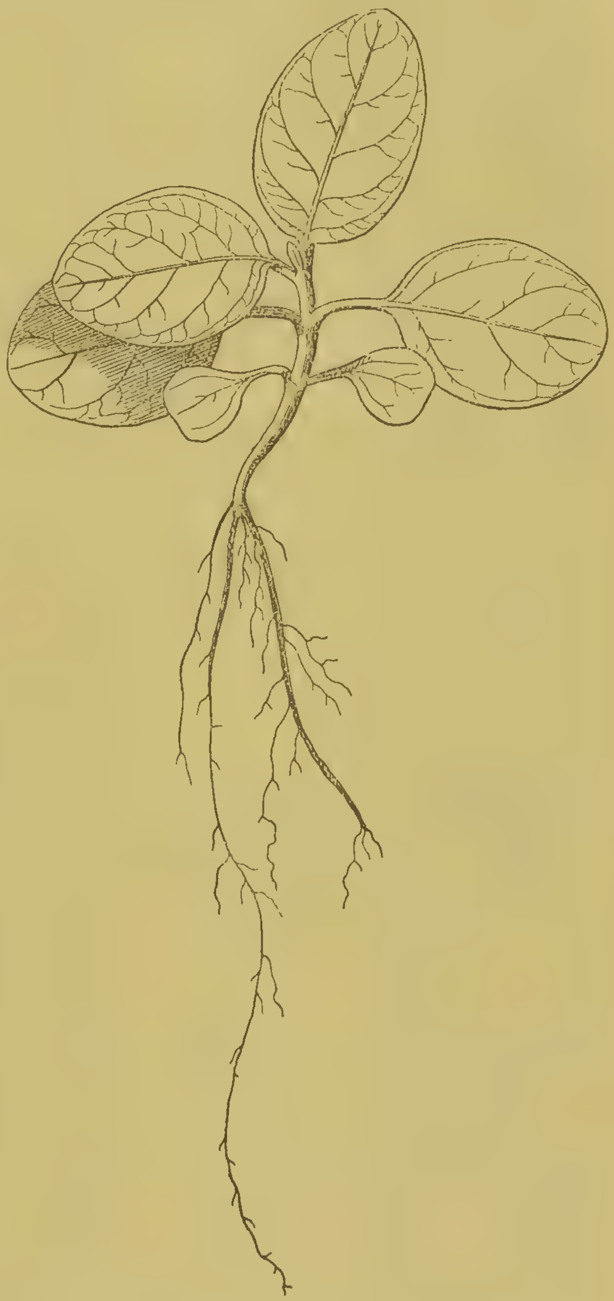

FIG. 581.—*Eranthemum leuconeurum.* Nat. size.

and as wide; petiole flattened above or biconvex, thinly hairy, 5–6·5 mm. long.

Stem herbaceous, dwarf, decumbent, terete, densely hairy with adpressed hairs, pale green; 1st internode 5-6 mm. long; 2nd 5–5·5 mm.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, reticulate, ciliate, somewhat hairy beneath and on the midrib above with adpressed hairs, otherwise glabrous, deep green with irregular white bands on the principal nerves, and closely marked with minute short striæ and little gland-like dots, much paler beneath or almost glaucous; petioles biconvex, or subterete, densely covered with adpressed whitish hairs.

First pair of leaves broadly oval, rounded at both ends or slightly cordate at the base.

Second pair broadly oval, less rounded at the apex than the first pair, and slightly more cordate at the base.

Asystasia coromandeliana, *Nees* (fig. 582).

Hypocotyl erect, terete, striated, glabrous, pale green, 1·8–2·2 cm. long.

Cotyledons obliquely or unequally rotund, entire, petiolate, suddenly tapered into the petiole, alternately incurvinerved, irregularly reticulate, glabrous, foliaceous, dull green above, pale or subglaucous beneath; lamina 2·2–2·6 cm. long, 2·3–2·5 cm. wide; petiole broadly channelled on the upper side, convex on the back, pubescent at the edges, otherwise glabrous, about 1·35 cm. long.

Stem erect, terete, bright green, longitudinally striate, thinly pubescent with whitish hairs curved downwards, furrowed on the sides alternating with the leaves next above; 1st internode 2·7–3 cm. long.

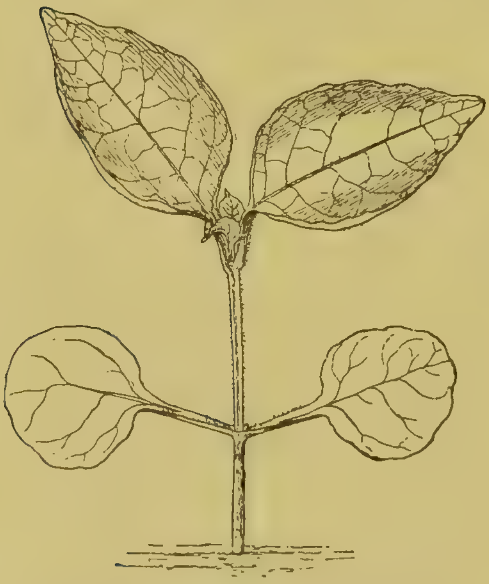

FIG. 582.—*Asystasia coromandeliana.* Half nat. size.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, and reticulate with the nerves branching, uniting and forming a submarginal wavy line running obliquely to the margin, pubescent on the midrib above and on the principal nerves beneath, light green and shining above, subglaucous beneath; petiole narrowly winged, semiterete, shallowly channelled above along the central ridge, pubescent with recurved hairs beneath, with a stout joint at its origin with the stem.

First pair ovate, obtuse, entire, suddenly narrowed at the base and decurrent, forming a wing to the petiole.

Schwabea ciliaris, *Nees.*

Hypocotyl long, striated, minutely hairy, 8·25–9 cm. long, light green with here and there a reddish tinge.

Cotyledons fleshy, oblong, obtuse, emarginate, petiolate, glabrous, green, one-nerved; petioles short, slightly hairy and slightly channelled on the upper face.

Stem erect, striated, hirsute, herbaceous, ultimately woody; 1st internode 5–5·5 cm. long; 2nd 1·5–2·5 cm.

First leaves simple, entire, cauline, opposite, decussate, petiolate, exstipulate, lanceolate, subacute, ciliate, slightly hairy, green, pinnatinerved; petioles short, hairy, channelled above.

Justicia bracteata, *Pohl.*

Hypocotyl erect, striated, covered with minute hairs, 3–4 cm. long, light green, tinged with red near the base.

Cotyledons rather fleshy, broadly obovate-oblong, slightly emarginate, shortly petiolate, glabrous, dark green, pinnatinerved like the leaves.

Stem erect, terete, herbaceous, minutely hairy; 1st internode 3–5 mm. long.

First leaves simple, entire, cauline, opposite, ovate-oval, obtuse, ciliated, covered with minute hairs, petiolate, exstipulate, light green, pinnatinerved.

Justicia procumbens, *Wall.*

Hypocotyl erect, terete, finely pubescent, 1·5–2·2 cm. long, light green or colourless.

Cotyledons subrotund, emarginate, obtuse, petiolate, glabrous, light green, indistinctly trinerved.

Stem erect, terete, pubescent; primary internodes very short.

First leaves simple, entire, cauline, opposite, very shortly petiolate, exstipulate, oval, obtuse, ciliate, pubescent, pinnatinerved, light green.

Dicliptera resupinata, *Juss.*

Hypocotyl erect, striated, covered with minute hairs, 8–12 mm. long, light green.

Cotyledons oblong, obtuse, emarginate, rather fleshy, unsymmetrical, glabrous except on the petioles, light green, trinerved.

Stem erect, herbaceous, striated or ribbed, covered with minute hairs; 1st internode 5–6 mm. long.

First leaves simple, entire, cauline, opposite, decussate, petiolate, exstipulate, ovate-oval, obtuse, covered with minute hairs, light green, pinnatinerved.

Peristrophe speciosa, *Nees* (fig. 583).

Primary root tapering downwards, with numerous fibrous rootlets ultimately superseded by strong lateral rootlets.

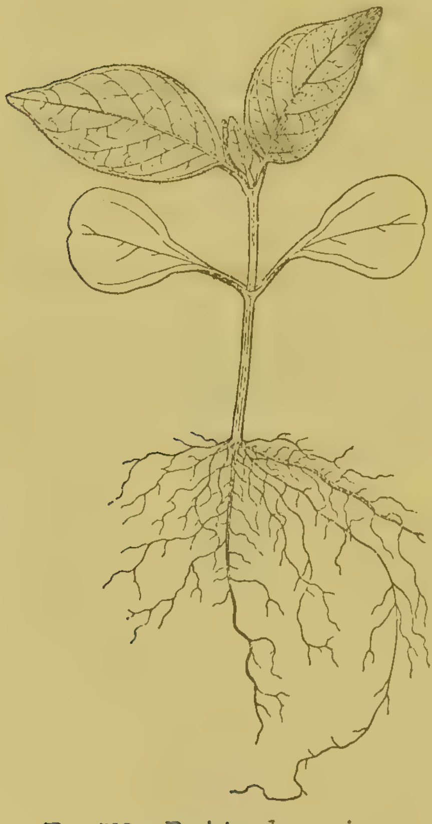

Fig. 583.—*Peristrophe speciosa.* Half nat. size.

Hypocotyl erect, terete, pubescent with short decurving hairs, pale green, 2–2·3 cm. above the soil.

Cotyledons large, obliquely and broadly rotund-obovate, slightly emarginate, alternately trinerved from the base with the nerves incurved and uniting with the midrib close beneath the apical notch, petiolate, glabrous except the petiole, light green above, paler beneath, suddenly tapered into the petiole; lamina 2·3–2·7 cm. long, 1·9–2·2 cm. wide; petiole semiterete, flattened above, dilated upwards into the lamina, pubescent with decurving hairs, 1–1·3 cm. long.

Stem herbaceous or subshrubby, erect, shallowly angled and furrowed, densely covered with short, decurving hairs; 1st internode 1·5–2 cm. long.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, unequal, alternately or suboppositely and incurvedly penninerved, with the nerves becoming more slender, and forming a submarginal line running to the apex of the leaf, light green above, paler beneath or subglaucous, pubescent on the nerves on both surfaces, with variously curved or bent hairs; petioles semiterete, slightly channelled above, rather slender, tapering somewhat upwards, densely covered with similar hairs.

First pair elliptic-ovate, obtuse, unequal in length, suddenly tapered at the base into the petiole.

The seedling of **P. bicalyculata**, *Nees*, very closely resembles the above, but has slightly broader cotyledons.

SELAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1126.

Fruit and Seed.—The pistil is superior, consisting of two carpels which unite to form a two-celled ovary, or the latter by abortion becomes obliquely one-celled while the plant is yet in flower. The ovules are solitary in each cell, suspended from the apex by a shortly filiform funicle, and anatropous. The fruit is small, indehiscent, included in the calyx, and two-celled, or breaks up into two cocci, or by the abortion of one of the original carpels it consists of only one coccus. The exocarp is thin and fleshy, or crustaceous, or hardened, rarely membranous. The sides of the seed-bearing cells are sometimes furnished internally with a layer of corky matter, or two small hollows; or the fruit between the cocci is furrowed. The seed is pendulous and solitary from the apex of each coccus and is oblong or terete, with a membranous testa. A fleshy endosperm is present. The embryo is axial, straight, and terete, with the cotyledons slightly broader than the superior radicle.

The fruit of Hebenstretia varies in width in different species, and is also affected in this respect according as one or both carpels mature. The seed is oblong-cylindrical, conforming to the interior of the cavities, and the shape seems to determine the narrowness of the cotyledons on germination.

Seedlings.—A number of the Hebenstretias are notable for the similarity which prevails between the cotyledons and the adult as well as the primary leaves. H. tenuifolia has linear cotyledons slightly broader towards the apex, tapering to a narrow base and bluntly carinate beneath with a prominent midrib. The first six leaves are in three opposite or subopposite pairs, followed by a large number of crowded alternate leaves which are linear and narrower than the cotyledons which they resemble very closely. The ultimate leaves are similar but minutely and distantly toothed at the margins. The cotyledons of H. dentata *var.* integrifolia are linear, rounded on the back, with a faint indication of a midrib, 1·6–1·8 cm. long and 1–1·5 mm. wide. The leaves are alternate with exception of the first pair, narrowly linear, rounded on the back like the cotyledons but longer, and entire, or the ultimate ones have a few blunt teeth near the apex.

Hebenstretia tenuifolia, *E. Mey.*

Primary root tapering downwards and giving rise to numerous slender flexuose fibres.

Hypocotyl erect, terete, finely pubescent, soon becoming firm in texture, 2–2·8 cm. long.

Cotyledons linear, obtuse, entire, broadest towards the apex and tapering gradually into a narrow, petiole-like base, glabrous, slightly channelled on the upper surface, with a prominent midrib beneath or somewhat carinate, 2–2·5 cm. long, and 2–2·5 mm. wide above the middle.

Stem erect, terete, or bluntly quadrangular in the lower part, finely pubescent; 1st internode 7–10 mm. long; 2nd and succeeding ones very short or hardly developed.

Leaves simple, cauline, the lower subopposite, and the upper ones crowded and alternate, exstipulate, sessile and tapering to a narrow petiole-like base, glabrous, opaque, channelled above and obtusely carinate beneath like the cotyledons, minutely, distantly and bluntly toothed at the margins.

Nos. 1–6. In three opposite or subopposite pairs; the rest crowded, narrower than the cotyledons, and alternate.

Hebenstretia dentata, *L.*, *var.* integrifolia.

Primary root long, tapering, flexuose, and giving rise to numerous flexuose fibres.

Hypocotyl erect, terete, finely pubescent, 1·8–2·2 cm. long.

Cotyledons linear-obtuse, or subacute, entire, channelled above, rounded on the back with a faint indication of a midrib, glabrous, deep green, 1·6–1·8 cm. long, 1–1·5 mm. wide.

Stem erect, terete, finely pubescent, brownish after a time; 1st internode 1–1·2 cm. long; 2nd 4–5 mm.; succeeding ones very short.

Leaves simple, cauline, alternate (first two opposite), exstipulate, sessile, channelled above, tapering to a narrow petiole-like base, rounded on the back with a faint indication of a midrib similar to the cotyledons, glabrous or slightly pubescent at the base on the under side.

Nos. 1 and 2. Opposite.

Nos. 3–30. Narrow, linear, subentire or with two or three blunt teeth near the apex, alternate and crowded, similar to the cotyledons but longer.

VERBENACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1131.

Fruit and Seed.—The ovary is superior and undivided, or four-furrowed or rarely shortly four-lobed. It consists of two carpels and normally in the young state is one-celled, with the placentas strongly intruded into the cavity, and revolute, dividing the ovary more or less perfectly into two cells, twin-ovuled, or one-ovuled by abortion. The cells afterwards become bilocellate by the development of spurious septa, and the four locelli then contain a single ovule each. In a few genera the ovary consists of four to five carpels divided into eight to ten locelli; and in the tribes Symphoremeæ and Avicennieæ the ovary of the young flower is already four-celled, or one-celled at the apex only. The ovules are more or less amphitropous except in Phryma, Clerodendron Kæmpferi, and possibly some others. They are inserted on the involute margins of the carpels, at the base, middle or towards the apex, with the micropyle inferior; rarely are they axial. The fruit is baccate or somewhat capsular, with a fleshy, succulent or thin and dry exocarp, and generally a hardened endocarp. Normally, the whole fruit or the endocarp alone is indehiscent at maturity, and two- to four-celled, or the fruit breaks up into one- to two-celled lignified pieces, or four rarely eight to ten one-celled pieces. The seeds are always in separate cavities, fixed laterally to the placentas and erect, or pendulous, oblong, obovoid or subglobose. The testa is mostly membranous except in Avicennia. A fleshy endosperm is present in the tribes Stilbeæ and Chloantheæ, but in all other cases it is very scanty or entirely absent. The embryo is straight and equals the length of the endosperm, or fills the whole seed where endosperm is wanting. The cotyledons are flat or thickened, quite free to the base or very rarely amalgamated for great part of their length into one piece. The radicle is generally very short and always inferior except in Phryma which contains a single species only, the ovule and seed of which are very anomalous.

Subcentral placentas occur in Avicennia as well as in members of the tribes Symphoremeæ and Caryopterideæ. Spurious septa are absent in the fruits of Espadæa. A fleshy, oily embryo with its cotyledons united to the middle occurs in Oxera, Amasonia and Symphorema. The embryo in Avicennia is naked with large plaited cotyledons.

The ovules of Clerodendron Kæmpferi are erect and anatropous with the micropyle inferior. The fruit breaks up at maturity into four drupe-like pieces, each containing a solitary oblong seed. The cotyledons are fleshy, plano-convex and fill the entire cavity of the seed to which they conform; they are, however, slightly auricled at the base in order to accommodate the minute, globular radicle.

Seedlings.—The cotyledons are all of simple types, and although five more or less distinct forms were observed, they may all be described as modifications of one another, dependent upon the size, and relative length and breadth of the seed. The simplest form is that seen in Vitex trifolia (fig. 585) which has small, oblong, obtuse cotyledons without apparent venation. The cotyledons of Verbena officinalis (fig. 584) are also small, but ovate, obtuse, with a distinct midrib and a few alternate, very faint lateral nerves. The petioles are slightly connate at the base. Lippia juncea in the seedling state at least bears considerable resemblance to a Verbena, and has ovate-oblong cotyledons with a venation similar to that of Verbena officinalis. The first pair of leaves are lanceolate, followed by two pairs which are oblong. All are bluntly serrate.

A third and distinct type is that represented by Stachytarpheta mutabilis which has broadly and roundly ovate, mucronate, and faintly penninerved cotyledons, truncate at the base. The petioles as well as the hypocotyl are hairy. The cotyledons of Rhaphithamnus longiflorus do not conform very closely to the above, but are roundly ovate and one-nerved.

The cotyledons of Callicarpa americana are small, roundly ovate, emarginate, trinerved, pubescent and ciliate.

The fifth type is represented by Clerodendron Kæmpferi (fig. 586) which has broadly ovate, shallowly and irregularly dentate, penninerved cotyledons, bearing some resemblance to the first pair of leaves but smaller.

Stachytarpheta mutabilis, *Vahl.*

Hypocotyl erect, terete, hairy, 2·2–2·5 cm. long, light green or colourless.

Cotyledons broadly and roundly ovate, obtuse, entire, petiolate, truncate at the base, glabrous, green, indistinctly pinnatinerved, like the leaves ; petioles flat, hairy.

Stem erect, terete, hairy ; 1st internode 3–4 mm. long.

First leaves simple, cauline, opposite-decussate, exstipulate, ovate, acute, serrate, pubescent, green, alternately pinnatinerved, petiolate ; petioles short, channelled, pubescent.

Verbena officinalis, *L.* (fig. 584).

Primary root tapering downwards and giving off numerous lateral fibres.

Hypocotyl short, erect, terete, glabrous, pale green or colourless, 3–5 mm. long.

Cotyledons ovate, obtuse, entire, tapering into the petiole, with a distinct midrib and a few short alternate ascending nerves discernible only by transmitted light, glabrous, light green above, paler beneath ; lamina 3·75–5 mm. long, 2·5–3 mm. wide ; petiole flat above, convex beneath, glabrous, 2·5–4·5 mm. long.

Stem herbaceous, erect, terete, hairy or pubescent, pale green ; 1st internode 1·5–2 mm. long ; 2nd 4–6 mm.

Leaves simple, cauline, opposite, exstipulate, petiolate, hairy with simple or gland-tipped hairs, alternately and ascendingly penninerved, with the nerves slightly incurved towards their apex, uniting with one another, and generally giving off branches only into the marginal serratures, bright green above, paler beneath; petioles semiterete, channelled above, hairy, with many of the hairs tipped with a gland.

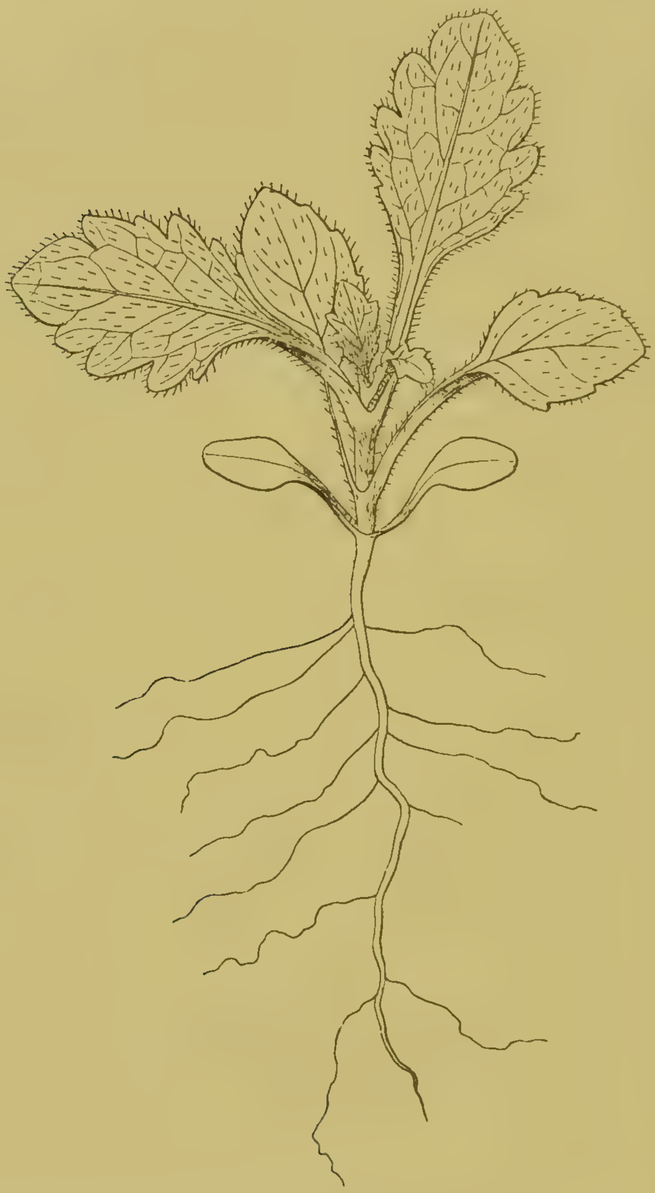

Fig. 584.—*Verbena officinalis*, × 2.

First pair of leaves oval or elliptic, obtuse, or often subovate, shallowly or obsoletely serrate-dentate.

Second pair larger, more deeply serrate-dentate with obtuse teeth the terminal one of which is largest.

Third pair elliptic-oblong, obtuse, incise serrate-dentate.

Verbena Aubletia, *L.*

Primary root as in V. officinalis.

Hypocotyl subflexuose, pubescent, pale pinkish-white, terete, 11 mm. long, 1·25 mm. thick.

Cotyledons very similar to those of V. officinalis, 6 mm. long, 3·5 mm. wide; petiole channelled above, connate at the base, pubescent, 6 mm. long.

Stem herbaceous, annual, obtusely quadrangular, erect (at least the primary one), ultimately much branched, with coarse villous hairs; 1st internode 1 cm. long; 2nd 8 mm.

Leaves coarsely villous on both surfaces, as well as on the petioles; petioles channelled above, subconnate at the base around the stem.

First pair ovate, obtuse, subcuneate at the base, subtrifid, penninerved; lateral lobes mere teeth; terminal lobe triangular-ovate, obtuse.

Second pair triangular-ovate, obtuse, subtrinerved at the base, pinnatifid; basal lobes longest, oblong, obtuse, and entire or again cut on the posterior or basal side.

Ultimate leaves triangular-ovate, obtuse, deeply pinnatifid, subcuneate at the base, coarsely hairy on both surfaces, deep green above, paler beneath with prominent venation; lobes more or less coarsely serrate on the posterior side; basal pair distinctly the largest and sublobulate on the posterior side.

Rhaphithamnus longiflorus, *Miers.*

Hypocotyl erect, square, hoary, almost colourless or reddish-green, from 1–2 cm. long.

Cotyledons roundly ovate, coriaceous, glabrous, petiolate, entire 6–10 mm. long, 5–6 mm. wide; dark green above, whitish beneath; venation indistinct but having one primary nerve.

Stem herbaceous, ultimately woody, erect, square, finely pubescent, light green; 1st internode 1–1·5 cm. long; 2nd about the same.

Leaves simple, serrated, upper ones coarsely, lower less so and sometimes almost entire, cauline, opposite, shortly petiolate, lanceolate, acute, glabrous, shining green above, lighter beneath; midrib with numerous ascending veinlets.

Callicarpa americana, *L.*

Hypocotyl erect, terete, finely pubescent, 6–8 mm. long, light green or colourless.

Cotyledons ovate-rotund, obtuse, emarginate, petiolate, slightly hairy, green, very indistinctly trinerved; petioles rather flat, shallowly channelled above.

Stem erect, terete, herbaceous, ultimately woody, thickly pubescent or hirsute; 1st internode 6–8 mm. long; 2nd shorter.

First leaves simple, cauline, opposite, decussate, exstipulate, petiolate, ovate-oblong or elliptic, obtuse, coarsely serrate, pubescent, green, lighter beneath, pinnatinerved; petioles hairy, rather long, shallowly channelled above.

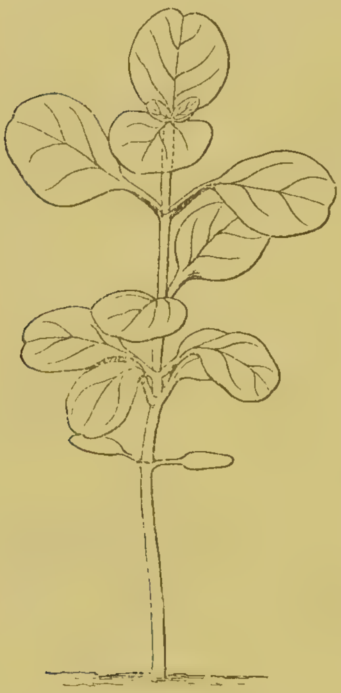

Fig. 585.
Vitex trifolia. Nat. size.

Vitex trifolia, *L.* (fig. 585).

Hypocotyl erect, terete, somewhat woody, pubescent, brownish, 2·2–3 cm. long.

Cotyledons oblong, obtuse, petiolate; lamina 6 mm. long, 2·5 mm. wide; petiole 3·25 mm. long.

Stem herbaceous or suffrutescent, erect, square, pubescent, purplish; 1st internode 7·5 mm. long; 2nd 2·5 mm.; 3rd 5·5 mm.; 4th 10 mm.; 5th 4 mm.

Leaves simple, ultimately digitate, cauline, opposite, exstipulate, petiolate, covered on both surfaces with a short, dense, adpressed pubescence, and somewhat hoary; petioles shallowly grooved on the upper surface, grooved on the back, and pubescent like the leaves.

First to sixth pairs inclusive, simple, rotund-obovate, emarginate, otherwise quite entire, alternately penninerved.

Clerodendron Kæmpferi, *Fisch.*

Ovary of two carpels, four-locellate, with each cell one-ovuled; ovule erect, anatropous; micropyle inferior.

Fruit baccate, two- to four-angled or -lobed when mature, glabrous, two- to four-celled, with a seed in each cavity that develops and comes to maturity, and falling away into as many nuts or drupes as there are locelli.

Seed ascending or erect from the base of the inner angle of the cell, somewhat compressed dorso-ventrally, and slightly curved longitudinally, and more or less wrinkled in that direction when dry, glabrous, whitish, exalbuminous; testa thin, membranous; hilum and micropyle basal, contiguous; funicle short, broad, and thin; chalaza apical, superior.

Embryo comparatively large, filling the entire seed and conforming to it in outline, slightly curved accordingly, colourless; cotyledons oblong, obtuse, entire, or very shallowly auricled at the base, lying in the broader plane of the seed with their backs to the axis of the fruit, thick, fleshy, plano-convex; radicle very minute, globose, obtuse, lying in the very base of the seed and projecting only slightly beyond the cotyledons.

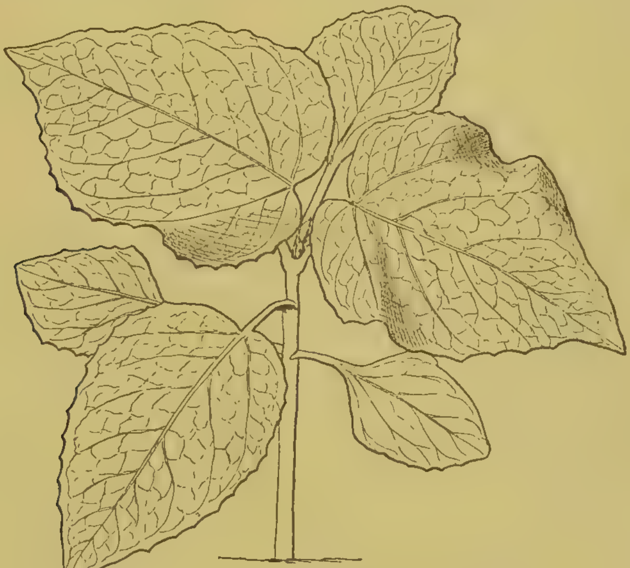

FIG. 586.—*Clerodendron Kæmpferi.* Nat. size.

Seedling (fig. 586).

Hypocotyl rather succulent, terete, 2 cm. long, 2·5 mm. thick, pubescent, bright green.

Cotyledons stalked, about 3 cm. long, 1·5 cm. wide, ovate, oblique at the base, obtuse, shallowly irregularly dentate towards the apex;

lower part entire, pubescent all over (as is the case with the whole plant above ground), rather thin, penninerved and reticulate, of a dark metallic green above, slightly paler beneath.

Stem with short internodes, herbaceous, terete, pubescent.

Leaves simple, cauline, opposite, decussate, exstipulate, petiolate, thin, dentate, alternately penninerved; nerves incurving, reticulate, pubescent all over.

First pair like the cotyledons only larger, and showing transition to the cordate form.

Second pair cordate, acute, wavy at the margin, dentate.

Third pair cordate, equal and regular, acute, finely dentate, alternately penninerved, reticulate.

LABIATÆ.

Benth. et Hook. *Gen. Pl.* ii. 1160.

Fruit and Seed.—The ovary is superior, syncarpous and four-partite to the base, more rarely shortly four-fid or -lobed beyond the middle. It consists of two carpels with their marginal and dorsal sutures so inflected as to form two pairs of one-celled cavities. The style is central and gynobasic. The ovules are solitary in each cell, and with few exceptions erect and anatropous. The fruit is most often included in the persistent calyx and consists of four lobes or nutlets or fewer by abortion; and each nutlet encloses a single seed and is indehiscent. The nutlets are dry, crustaceous or hard, rarely fleshy or drupaceous, smooth, tuberculate, or roughly reticulate, rarely surrounded with a wing-like appendage, and attached near the base by a small oblique or lateral areola to that part of the ovary bearing the style. The seed conforms to the interior of the nutlet and is attached by the very base or laterally near the base to the placenta, and is rarely incurved the testa is membranous. Endosperm is scanty or altogether wanting. The embryo again conforms to the seed and has flat or plano-convex, slightly fleshy cotyledons parallel or rarely transverse to the axis of the fruit. The radicle is short, inferior and straight, or rarely incurved with incumbent or recumbent cotyledons.

The ovary is usually stipitate in Scutellaria as is the shortly lobed ovary in the tribes Prostanthereæ and Ajugoideæ.

The nutlet is depresso-globose in Salazaria and Scutellaria, fleshy in Gomphostemma and subdrupaceous in other members of the tribe Prasieæ. The radicle is long and incurved in Catopheria, with accumbent cotyledons. The seed is transverse to the axis in Salazaria and Scutellaria with an incurved radicle and incumbent cotyledons.

About five more or less distinct types of seeds have come under my notice differing chiefly in shape, dependent upon that of the nutlet containing them. One of the simplest forms is that represented by Salvia Sclarea (fig. 589) which has small obovoid seeds with a straight embryo conforming to the interior. The cotyledons are oval, plano-convex, and slightly auricled at the base to accommodate the radicle. There is a thin film of endosperm in the seed, but so small as to be practically of no importance. The seed of Thymus Mastichina differs in being very much smaller and globose with suborbicular cotyledons.

A second type is that shown by Salvia argentea. The nutlet and seed are broadly oblong-oval. The cotyledons are similar in outline, plano-convex and rather deeply auricled at the base. The transverse section of the nutlet, seed and embryo is elliptic, or slightly trigonous. Teucrium multiflorum conforms pretty closely to this type, but the nutlets are muricate or covered with little tubercles.

Salvia verbenacoides has a smooth nutlet, broadly oval in transverse section, but otherwise conforming to S. argentea.

The nutlet of Ocimum Basilicum is oblong-ovate with rather a notable constriction about the middle. The cotyledons conform to this outline and are shortly auricled at the base. In transverse section the nutlets are broadly oval.

The nutlets of Nepeta nuda (fig. 593) are notably trigonous in transverse section, broadly oblong-oval in outline, and scabrid or muricate all over the surface. The cotyledons in conforming to this characteristic shape are of different forms or differently disposed while yet in the seed. That on the ventral aspect is convexo-concave, with a blunt angle next the axis of the fruit, while the other is biconvex and fits into the bend of its fellow. Both are very deeply auricled at the base and fold over the back of the radicle nearly concealing all but the tip. The nutlets of Lallemantia peltata are obovoid and smooth, but the transverse section is similar to that of the last, and the cotyledons are broadly obovate, shallowly auricled, and similarly disposed to those of Nepeta nuda in order to conform to the shape of the seed. The nutlets, the seed and the very short stout radicle of Prunella grandiflora resemble those of Lallemantia peltata.

The nutlet and seed of the species of Scutellaria noticed differ from all others in the Order. The nutlet of S. galericulata is oval in outline, dorsally compressed with a ridge on the ventral face to accommodate the radicle, and rugose or tuberculated all over the surface. The ovule and seed are campylotropous. The cotyledons are oval in outline, plano-convex, entire, and incumbent. The radicle is folded along the ventral aspect of the seed, and is about half the length of the cotyledons. S. altissima closely conforms to the above in every respect, except that the radicle is slightly longer or about two-thirds the length of the seed. The hilum is therefore above the middle of the seed on the ventral aspect. S. peregrina is closely similar to the above, but the radicle is three-fourths as long as the cotyledons and seed, and is accommodated in a ridge on the ventral face of the latter. The absence of the auricles at the base of the cotyledons seems to be peculiar to this genus, and is brought about by the folding of the radicle on the ventral face of the seed, instead of this being straight and situated between the bases of the two cotyledons.

Seedlings.—The cotyledons are all of simple types. They vary slightly in form according to that of the seed from which they spring, but often undergo considerable modification after germination. Many, though by no means all, of those observed may be reduced to three types. One of the more common is that represented by Salvia Columbariæ (fig. 590) which has triangular, obtuse, emarginate cotyledons rather deeply auricled at the base. This form is due to that of the seed, which the embryo wholly occupied as explained above. The basal auricles of the cotyledons although always present in the seed often become nearly obliterated by growth after germination when they spread out, making the base of the lamina more or less perfectly truncate. This is nearly the case in S. triangularis which has indistinctly penninerved cotyledons, but otherwise conforms to the type.

The cotyledons of Nepeta tuberosa vary slightly between triangular and orbicular and are emarginate. The cotyledons of Salvia hispanica are relatively broader, trinerved and finely pubescent. Those of Nepeta nuda (fig. 594) and Salvia argentea differ in being somewhat more rounded at the apex, and more deeply cordate at the base. Those of the former are notable for a cavity or depression at the base of the lamina caused by the radicle and plumule while yet in the seed.

A second type having reniform emarginate cotyledons occurs in Nepeta Glechoma. The cotyledons of Ocimum Basilicum and Perilla nankinensis (fig. 587) are more or less perfectly truncate at the base and emarginate. The basal auricles present in the seed get obliterated by spreading out after germination. A slight modification of this type occurs in Salvia clandestina which has trinerved entire cotyledons, truncate at the base. A third type is represented by Dracocephalum peltatum (fig. 592) which has suborbicular emarginate cotyledons distinctly auricled at the base.

Elsholtzia cristata, Lallemantia iberica, and L. canescens agree pretty closely with this type, as also does Monardella Pringlei. The small size of the cotyledons and the length of the petioles of the first pair of leaves, as compared with those that follow, are noteworthy. The cotyledons of Eremostachys laciniata are faintly trinerved and differ from the type chiefly in being more elongated and roundly oblong.

Acanthomintha ilicifolia (fig. 588) constitutes a fourth type having small orbicular cotyledons, auricled at the base but otherwise entire.

The cotyledons of Salvia verbenacoides (fig. 591) differ slightly from those of the above in being subtruncate at the base. Those of Saturcia hortensis differ only in having slightly wider basal auricles. The first pair of leaves are broadly oval and entire.

The ovate-oblong cotyledons of Teucrium Botrys (fig. 595) represent a very unusual form and, as far as I am aware, occur only in the tribe Ajugoideæ. The leaves are glandular-pubescent and cuneate at the base, and show an interesting evolution somewhat on a ternary plan. The first pair are simply crenate; the second pair lobulate; while the third and fourth pairs are deeply trifid and tripartite respectively with the lobes cuneate and more or less distinctly trifid. The cotyledons of Ajuga Chamæpitys (fig. 596) are much smaller and oblong, but otherwise conform to those of Teucrium Botrys. The first pair of leaves are oblong or spathulate and entire; the second pair lanceolate with a tooth on each side; the third and fourth cuneate and trifid at the ends, while the fifth and sixth pairs are pinnatifid.

The cotyledons of Galeopsis pyrenaica are obovate or oblong-obovate, emarginate, with small ovate or triangular auricles, and thus differ from any of the above types.

Those of G. Ladanum are also unique in being sub-orbicular, emarginate with a sudden contraction a little above the base of the lamina. The first pair of leaves are broadly ovate and crenate; while the next two pairs are oblong-ovate. All are penninerved.

Ocimum Basilicum, *L.*

Hypocotyl erect, terete, minutely pubescent, 1–2 cm. long, with a reddish tinge.

Cotyledons fleshy, unequal, triangular or reniform, emarginate, slightly cordate at the base, petiolate, light green, glabrous except on the petiole; midrib apparent only at the base.

Stem short, erect, herbaceous; primary internodes but slightly developed.

First leaves simple, cauline, opposite, slightly toothed, ovate-lanceolate, acute, sessile, glabrous, pale green, pinnatinerved.

Elsholtzia cristata, *Willd.*

Hypocotyl erect, terete, finely pubescent, 9–12 mm. long, almost colourless or stained with red.

Cotyledons oblong-rotund, obtuse, emarginate, slightly auricled at the base, subfleshy, petiolate, glabrous, green, without any apparent venation; petioles hairy, short, shallowly channelled on the upper side.

Stem erect, square, pubescent; 1st internode 3–5 mm. long.

First leaves simple, cauline, opposite, decussate, shortly petiolate, exstipulate, ovate, obtuse, crenate-serrate, covered with hairs, green, pinnatinerved.

Perilla nankinensis, *Decne.* (fig. 587).

Primary root vertical, slender, grey, with a few lateral fibres.

Hypocotyl 2–3 cm. long, 1 mm. thick, terete, pubescent, colourless.

Cotyledons including petiole 1 cm. long, 1 cm. wide, unequal, shortly stalked, subreniform, obtuse, emarginate, otherwise entire, obscurely nerved, pubescent, dark green above, purplish beneath, flat, not very thick or persistent.

Stem erect, obtusely angular, substriate, thinly pubescent, deep purplish-red; hairs deflexed or hooked backwards; 1st internode 3·3–4 cm. long, rather variable in length; 2nd 4–6 mm.

Leaves cauline, opposite, simple, exstipulate, petiolate, sparsely hairy on both surfaces and pubescent on the midrib; hairs thickened at the base, hyaline above and tipped with violet.

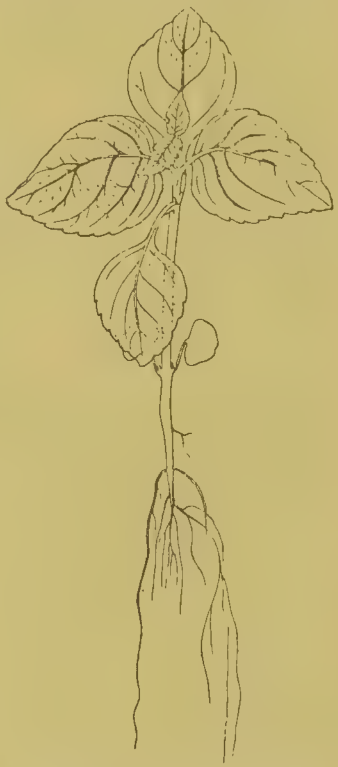

Fig. 587.—*Perilla nankinensis.* Half nat. size.

First pair rotund-ovate or elliptic, obtuse, obsoletely serrate-crenate, penninerved, a deep black purple; petiole flattened above, convex beneath, pubescent on both surfaces.

Second pair broadly rotund-ovate, obtuse, crenate-serrate, penninerved, similar to the first pair except in the larger size and greater breadth at the base.

Monardella Pringlei, *A. Gray.*

Hypocotyl short, erect, terete, minutely pubescent, 2-3 mm. long, reddish-green.

Cotyledons small, subrotund, emarginate, cordate at the base, petiolate, glabrous except on the petioles, fleshy green, without any apparent venation.

Stem erect, square, minutely pubescent; 1st internode about 1·5 cm. long; 2nd 1–1·2 cm.

First leaves simple, entire or minutely crenate, cauline, opposite, decussate, petiolate, exstipulate, lanceolate-oblong, obtuse, minutely pubescent, green, distinctly and alternately pinnatinerved; petioles of the first pair very long; 2nd and 3rd considerably shorter.

Satureia hortensis, *L.*

Hypocotyl erect, terete, 6–10 mm. long, reddish-brown, minutely pubescent.

Cotyledons subrotund, obtuse, entire, auricled at the base, petiolate, glabrous, green, indistinctly one-nerved; petioles rather long, hairy, slightly channelled on the upper side.

Stem erect, square, finely pubescent; 1st internode 2–3 mm. long.

First leaves simple, entire, cauline, opposite, decussate, petiolate, exstipulate, broadly oval, obtuse, minutely pubescent, green, pinnatinerved.

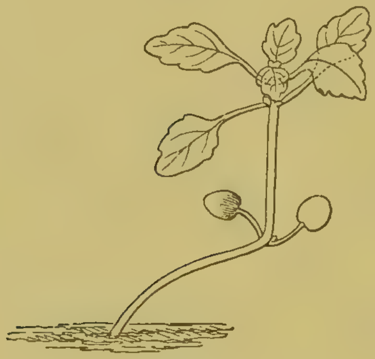

FIG. 588.
Acanthomintha ilicifolia.
Nat. size.

Acanthomintha ilicifolia, *Wright* (fig. 588).

Primary root annual, fibrous.

Hypocotyl slender, wiry, terete, pubescent, purple, frequently bent or twisted, 1·8 cm. long or shorter.

Cotyledons rather fleshy, rotund, subcordate at the base, entire or slightly emarginate at the apex, glabrous; petiole pubescent, flattened above, 4–5 mm. long.

Stem erect, obtusely quadrangular, pubescent, purple; 1st internode 1·3 cm. long; 2nd 2 mm.; stem leafy, branched from the base.

Leaves simple, cauline, opposite, decussate, petiolate, exstipulate, pubescent, ultimately glabrous; petioles subterete, flattened above or channelled, pubescent.

First pair ovate-oblong, obtuse, crenate-serrate, with ascending nerves.

Second pair ovate, obtuse, obtusely serrate, cuneate at the base, with ascending nerves.

Third pair ovate, obtuse, more deeply serrate than the second pair.

Ultimate leaves rotund or ovate-cuneate, narrowed to a short petiole, alternately and ascendingly penninerved, coarsely and bluntly toothed.

Bracts opposite, orbicular, often larger than the leaves, finely reticulate with long, spinous, diverging teeth.

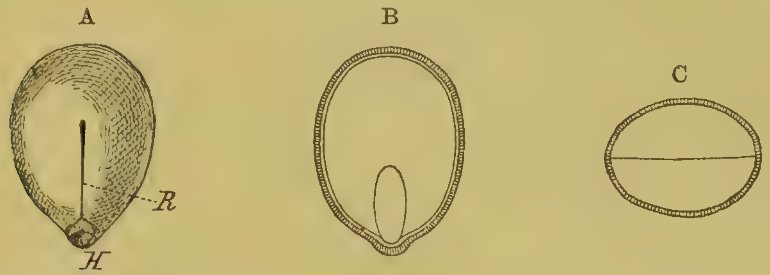

FIG. 589.—*Salvia Sclarea.* A, ventral aspect of seed, × 8: *H*, hilum; *R*, raphe. B, longitudinal section of seed, × 8. C, transverse section of seed, × 8.

Salvia Sclarea, *L.* (fig. 589).

Fruit separating into four nutlets (or fewer by abortion), each consisting of an outer soft integument and an inner thick and leathery one, and containing one seed.

Seed obovoid, pale brown, very finely reticulate; testa thin, membranous; hilum basal and slightly oblique; raphe ventral or on the same side to which the hilum is directed, passing along to a point above the middle of the seed; chalaza small, punctiform, above the middle of the seed.

Endosperm forming an extremely thin layer surrounding the embryo, and adhering to the testa.

Embryo straight, large, colourless, filling the interior of the seed and conforming to it; cotyledons plano-convex, following the outline of the seed and accordingly broadly orbicular or oval in longitudinal section, entire at the apex, slightly notched at the base; radicle very short, stout, almost included between the cotyledons.

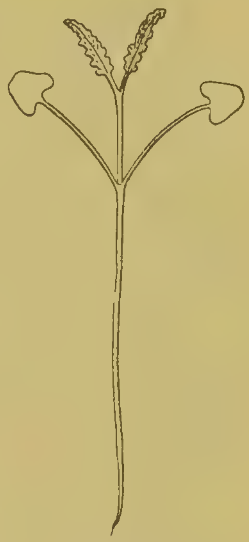

FIG. 590.
Salvia Columbariæ.
Nat. size.

Salvia Columbariæ, *Benth.* (fig. 590).

Primary root small, eventually throwing off a few lateral fibres.

Hypocotyl 2–3 cm. long, ·75 mm. thick, terete, glabrous, colourless.

Cotyledons.—Lamina 3–4 mm. long, 4–5 mm. wide, triangular, emarginate, cordate at the base, pubescent, very obscurely nerved, not very persistent; petiole slender, 1–1·5 cm. long, ·5 mm. thick, finely pubescent.

Stem succulent, slightly pubescent, rounded, light green; internodes about 1 cm. long, ·75 mm. thick, or altogether undeveloped in the open ground in the seedling stage.

Leaves radical and cauline, simple, opposite, decussate, exstipulate, petiolate, rugose, pubescent or subscabrous from short white hairs; petioles channelled above, convex beneath, pubescent.

First pair linear-oblong, obtuse, pinnatifid; lobes shallow, roundish-triangular.

Second pair oblong, obtuse, pinnatifid with shortly oblong, obtuse lobes.

Salvia triangularis, *Thunbg.*

Primary root tapering downwards with several long, strong lateral rootlets.

Hypocotyl erect, terete, pubescent, 4–6 mm. long, light green or colourless.

Cotyledons very similar to those of S. Columbariæ, but glabrous and indistinctly pinnatinerved, like the leaves in their venation; petioles 5–6 mm. long.

Stem short, erect, herbaceous, pubescent, primary internodes but slightly developed.

First leaves ovate, obtuse, ciliated, simple, crenate, petiolate, thickly pubescent, light green, distinctly pinnatinerved.

Salvia hispanica, *L.*

Hypocotyl as in S. triangularis, 8–12 mm. long.

Cotyledons widely triangular, emarginate, cordate at the base, shortly petiolate, minutely pubescent, light green, indistinctly trinerved.

Stem erect, minutely pubescent.

Salvia argentea, *L.*

Fruit consisting of four dorsally compressed, almost triangular nutlets.

Seed conforming in shape to the nutlet, exalbuminous, 2·5–3 mm. long; testa smooth, membranous; hilum inconspicuous.

Embryo straight, filling the whole of the seed, colourless; cotyledons broadly oblong, plano-convex, obtuse, about the same width throughout, with rather large auricles, otherwise entire, lying the broad way of the seed, with their faces to the axis; radicle short, terete, obtuse, lying close to the hilum.

Seedling.

Primary root stout, tapering, giving off lateral adventitious rootlets.

Hypocotyl terete, stout, fleshy, wrinkled transversely, 6–9 mm. long, 1·5–2 mm. thick.

Cotyledons rotund, obtuse, auricled at the base, rather fleshy, glabrous, 1 cm. long, 1·3 cm. wide; petiole subterete, channelled above, coarsely pubescent, 1·2 cm. long.

Stem undeveloped in the early stage of the plant.

Leaves simple, radical, petiolate, rugose, woolly on both surfaces with long white hairs, especially when young.

First pair oblanceolate, obtuse, obtusely serrate, gradually tapering at the base into a short petiole, nerves ascending.

Second pair ovate-oblong, obtuse, crenate-serrate, with ascending and much anastomosing veins.

Salvia clandestina, *L.*

Hypocotyl short, erect, finely pubescent, 4–5 mm. long, light green or colourless.

Cotyledons oblate or subreniform, entire, obtuse, with long petioles, glabrous, dark green, trinerved.

Stem short, erect, herbaceous, quadrangular; 1st internode 2–2·5 mm. long; 2nd shorter and so near the first that the second pair of leaves appear as though they formed a whorl of four with the first pair.

Leaves cauline, ovate or oval, obtuse or subacute, crenate, somewhat wrinkled, pubescent, with amplexicaul petioles, dark green; midrib with numerous ascending veinlets.

Salvia verbenacoides, *Brot.* (fig. 591).

Primary root long, stout, fleshy, tapering, colourless, with a few lateral rootlets, especially near the top.

Hypocotyl very short, stout, fleshy, subterranean, colourless, 4·5 mm. long.

Cotyledons roundly triangular, subtruncate or slightly notched at the base, fleshy, petiolate; lamina glabrous, 5 mm. long, 6 mm. wide; petiole hairy, convex on upper and under sides, 8 mm. long.

Stem herbaceous, elongated when about to flower.

Leaves simple, radical, cauline, rugose, deep green above, paler beneath, finely pubescent or scaberulous on both surfaces, coarsely hairy on the midrib when young, ultimately losing these hairs; petioles channelled above, dilated and clasping at the base, convex beneath, coarsely hairy, purplish.

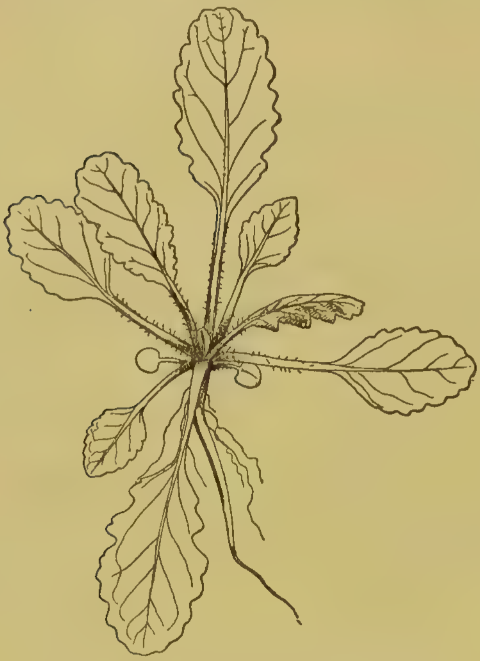

Fig. 591.—*Salvia verbenacoides.* Half nat. size.

First pair ovate, obtuse, cuneate at the base, crenate.

Second pair ovate-oblong, obtuse, cuneate at the base, crenate.

Third pair oblong, obtuse, cuneate at the base, rather coarsely crenate.

Fourth pair developing unequally and appearing alternate, oblong, obtuse, doubly crenate.

Ultimate radical leaves oblong, obtuse, obtusely lobulate, crenate, unequal at the base, reticulate; petiole long, shallowly channelled with a thickened margin. Cauline leaves similar, gradually shorter with shorter petioles.

Dracocephalum peltatum, *L.* (fig. 592).

Primary root long, flexuose, with numerous lateral rootlets. Rootstock perennial.

Hypocotyl short, stout, merging into the root.

Cotyledons foliaceous, glabrous, petiolate; lamina oblong-reniform, 9 mm. long, 8 mm. wide; petiole semiterete, flattened above, finely pubescent, 12 mm. long.

Stem herbaceous, elongated when about to flower.

Leaves simple, radical (and ultimately cauline), opposite, exstipulate, petiolate, dentate-serrate, finely pubescent on both sides; petioles channelled on the upper side, dilated at the base, pubescent.

First pair small, ovate, obtuse, cordate at the base.

Second pair rotund-cordate, obtuse.

Third pair cordate, obtuse.

Fourth pair oblong, obtuse, cordate at the base.

Ultimate leaves cordate, obtuse, obtusely dentate-serrate, five-nerved at the base and deeply cordate.

Nepeta nuda, *L.* (fig. 593).

Fruit of four nutlets, separating when mature, oblong-oval, convex and flattened dorsally, obtusely angled on the ventral aspect, scabrid, black, with a white, transverse scar a little above the base on the ventral aspect; pericarp separable into an outer rather soft dark layer, and an inner paler leathery one.

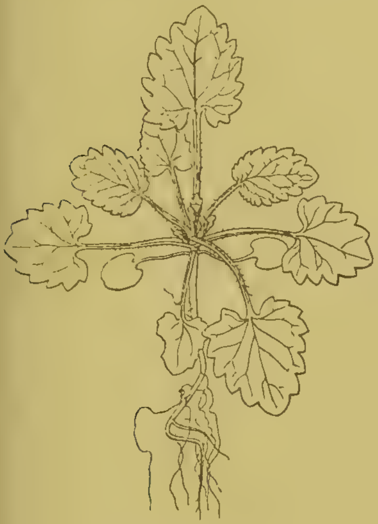

FIG. 592.—*Dracocephalum peltatum.* Half nat. size.

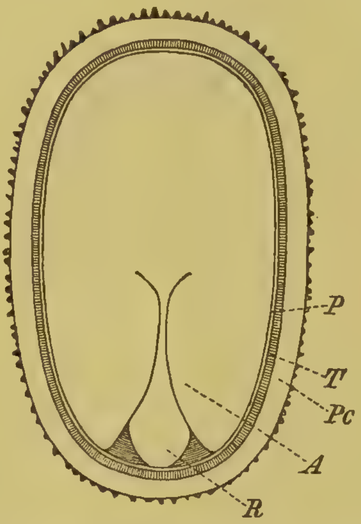

FIG. 593.—*Nepeta nuda*, × 25. Longitudinal section of nutlet: *R*, radicle; *A*, auricle of cotyledon; *Pc*, pericarp; *T*, testa; *P*, endosperm.

Seed conforming to the shape of the nutlet, and filling it entirely if properly developed, pale grey; hilum nearly or quite basal; micropyle contiguous, basal; raphe ventral; chalaza some distance below the apex on the ventral aspect.

Endosperm forming a thin film lining the interior of the testa, white.

Embryo straight, filling the entire seed with the exception of the film of endosperm, colourless; cotyledons oblong-oval, rounded at the apex, auricled at the base, one concavo-convex, the other biconvex, as long as the cavity of the seed; auricles produced along the sides and partly over the back of the radicle to fill up the space in the seed; radicle oblong, obtusely pointed, protruded only a little way beyond the cotyledons.

Seedling (fig. 594).

Primary root slender, tapering, normal.

Hypocotyl erect, terete, densely glandular-pubescent, 3–4 mm. above the soil.

Cotyledons rotund-cordate, obtuse, entire, rather deeply auricled at the base, petiolate, rather densely glandular-pubescent on both surfaces, dull opaque green or slightly hoary with a few alternate incurved nerves seen with difficulty even by transmitted light; lamina 3·5–5 mm. long, 2·5–5 mm. wide; petiole semiterete, grooved above, densely glandular-pubescent, pale green, 4·5–6·5 mm. long.

Stem herbaceous, erect, densely glandular-pubescent, obtusely quadrangular; 1st internode 1 mm. long.

Leaves simple, cauline, opposite, exstipulate, petiolate, alternately, ascendingly incurvinerved, densely glandular-pubescent on both surfaces, dull green or somewhat hoary; petiole semiterete, channelled above, densely glandular-pubescent, pale green.

First pair rotund-obtuse, unequally crenate suddenly narrowed into the petiole, almost truncate, few-nerved.

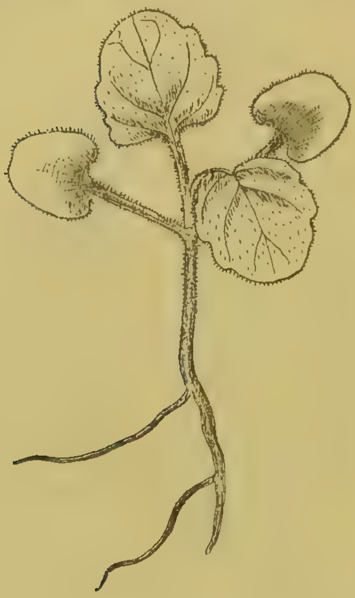

FIG. 594.—*Nepeta nuda*, × 2.

Nepeta Glechoma, *Benth.*

Hypocotyl succulent, pubescent, pale green, about 4 mm. above ground.

Cotyledons reniform, emarginate, pale green, somewhat fleshy, pubescent, 5·25 mm. long, 6·75 mm. wide; petiole 5 mm. long.

Stem herbaceous, erect, ultimately procumbent, throwing out prostrate branches from the axils of the cotyledons, square, pubescent with a few coarse interpetiolar hairs at the nodes; 1st internode 1 mm. long; 2nd 1·5 mm.; 3rd 2 mm. Flowering stems short, erect.

Leaves densely pubescent on both surfaces and thinly covered with coarse jointed hairs, deep green above, paler beneath; petioles channelled above, pale green, densely pubescent with short decurved hairs intermixed with a few scattered long ones.

First pair reniform, crenate, seven-toothed.

Second pair rotund-cordate, crenate, nine-toothed, five-nerved at the base with a few alternate ascending nerves on the upper half.

Ultimate leaves reniform or broadly cordate with a deep basal sinus, and rounded more or less open or overlapping auricles, crenate, five-nerved, reticulate, rugose, deep green and scabrously hairy above, paler beneath, punctate and hairy on the nerves.

Nepeta tuberosa, *L.*

Hypocotyl 3–16 mm. long, about 1 mm. thick, soft and herbaceous, densely pubescent.

Cotyledons petiolate, triangular or rotund, emarginate, truncate at the base or subauricled, pale green, densely pubescent and subglandular on both surfaces, as is the terete petiole.

Stem erect, herbaceous, pale green or suffused with red, obtusely quadrangular, densely pubescent and subglandular; internodes variable in length according to cultivation.

Leaves cauline.

First pair rotund-cordate, obtuse, subcrenate, penninerved, rugose, densely pubescent on both surfaces and subglandular, herbaceous and soft in texture; petiole terete, channelled above, densely pubescent and subglandular.

Second pair more deeply cordate at the base, and more deeply crenate.

Lallemantia peltata, *Fisch. et Mey.*

Fruit consisting of four dorsally compressed, triangular nutlets.

Seed conforming to the shape of the nutlet, flattened, about 1–1·5 mm. long, exalbuminous; testa membranous; hilum inconspicuous.

Embryo straight, colourless, filling the seed; cotyledons broadly oblong or obovate, obtuse, entire, rather unequal, lying face to face; one concavo-convex, the other biconvex, lying the broad way of the seed; radicle short, terete, obtuse.

Lallemantia canescens, *Fisch. et Mey.*

Hypocotyl erect, terete, glabrous, 1·2–1·6 cm. long, light green or colourless.

Cotyledons suborbicular, auricled or cordate at the base, emarginate, glabrous, pinnatinerved as in the leaves; petioles long.

Stem erect, square, glabrous; 1st internode 5–6 mm. long; 2nd shorter.

First leaves simple, opposite, one growing faster than another, ovate-oblong, obtuse, crenate, exstipulate, glabrous, green, pinnatinerved; petioles long.

Lallemantia iberica, *Fisch. et Mey.*

Hypocotyl minutely pubescent, 3–4·5 cm. long.

Cotyledons very like the last species, reniform-orbicular, deeply auricled at the base, glabrous except on the petioles.

Stem.—Primary internodes undeveloped.

First leaves ovate-lanceolate, acute, slightly toothed, minutely pubescent, pinnatinerved.

Galeopsis pyrenaica, *Bartl.*

Primary root an abruptly tapering taproot, giving off numerous fibrous lateral rootlets.

Hypocotyl erect, terete, glabrous, pale green, becoming stronger upwards, 3–6 cm. long.

Cotyledons broadly oblong or oblong-obovate, or obovate, petiolate, emarginate, auricled at the base with two small ovate or triangular obtuse or subacute auricles, very indistinctly trinerved with the nerves running from the base and becoming incurved to the apex; lamina glabrous, 1–1·5 cm. long, ·8–1·2 cm. wide; petiole slightly connate at the base, semiterete, channelled above, ciliate at the margins ·9–1·5 cm. long.

The shape of the cotyledons is very unusual for this Order.

Stem herbaceous, erect, obtusely quadrangular, hairy, with many of the hairs glandular, especially the shorter ones; 1st internode ·8–3 cm. long.

Leaves simple, cauline, opposite, exstipulate, hairy on both surfaces and thinly glandular, petiolate, penninerved, with ascending nerves running into the sinus, not into the teeth; petiole semiterete, channelled above and hairy.

First pair broadly oblong, obtuse, minutely emarginate, bluntly and rather distantly serrated.

Galeopsis Ladanum, *L.*

Hypocotyl covered with minute hairs, reddish, 1–1·5 cm. long.

Cotyledon rotund, ovate-obtuse, emarginate, petiolate, glabrous except on the petiole, green, indistinctly one-nerved, constricted a little above the base.

Stem erect, square, herbaceous, pubescent, annual; 1st internode 2–2·5 cm. long; 2nd 4–5 mm.

First leaves simple, cauline, opposite, exstipulate, petiolate, varying from ovate to lanceolate, obtuse, obtusely serrate, pubescent, light green, pinnatinerved; petioles short, pubescent, channelled on the upper face.

Eremostachys laciniata, *Bung.*, *var.* pinnatisecta.

Hypocotyl erect, terete, glabrous, 2–4 mm. long, light green or colourless.

Cotyledons thick, fleshy, unequal, broadly oblong, emarginate, obtuse, auricled at the base, petiolate, glabrous, indistinctly tri-nerved, green. The emargination is due to after-growth, for the cotyledons are entire at first.

Primary internodes of the stem undeveloped.

First leaves radical, ovate, obtusely crenate, covered with hairs, light green, pinnatinerved; petiole long, hairy, channelled on the upper side.

Teucrium Botrys, *L.* (fig. 595).

Primary root tapering, long, slender, colourless, with short lateral fibres, annual.

Hypocotyl subterranean, terete, glandular-pubescent, tapering gradually into the root.

Cotyledons rather fleshy, glandular-pubescent, petiolate; lamina ovate-oblong, obtuse, submucronate, 5 mm. long, 4 mm. wide.

Stem annual, short and erect at first with very shortly developed internodes, ultimately long and procumbent.

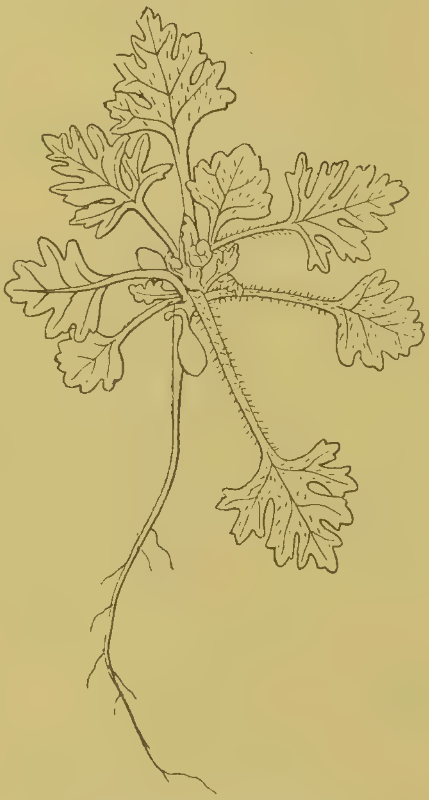

Fig. 595.—*Teucrium Botrys.* Nat. size.

Leaves simple, radical and cauline, opposite, decussate, exstipulate, petiolate, opaque green, densely glandular-pubescent on all parts; petioles channelled above, convex beneath, somewhat dilated at the base; nerves of leaf all sunk.

First pair triangular, obtuse, nearly truncate at the base, rather deeply crenate.

Second pair triangular, obtuse, lobulate; lobes entire, or basal ones with a tooth on the posterior side.

Third pair triangular, pinnatifid; basal lobes unequally bifid or trifid; next pair of lobes tridentate.

Fourth pair triangular and similar to the last, but the segments are more slender and more numerous.

Ajuga Chamæpitys, *Schreb.* (fig. 596).

Primary root tapering, flexuose, giving off lateral, fleshy, much branched secondary roots.

Hypocotyl ascending, terete, fleshy, glabrous, reddish, 8 mm. long.

Cotyledons oblong, obtuse, glabrous, petiolate; lamina 4 mm. long, 1·5 mm. wide; petiole 2 mm. long.

Stem herbaceous decumbent, branching.

Leaves simple, radical and cauline, opposite, exstipulate, petiolate, gradually decurrent on the petiole almost or quite to the base except in the primary leaves, deep green above, glaucous beneath and strongly ribbed, revolute at the margins.

First pair small, oblong, obtuse or subacute, entire, distinctly petiolate; lamina 4·5 mm. long, 2·25 mm. wide.

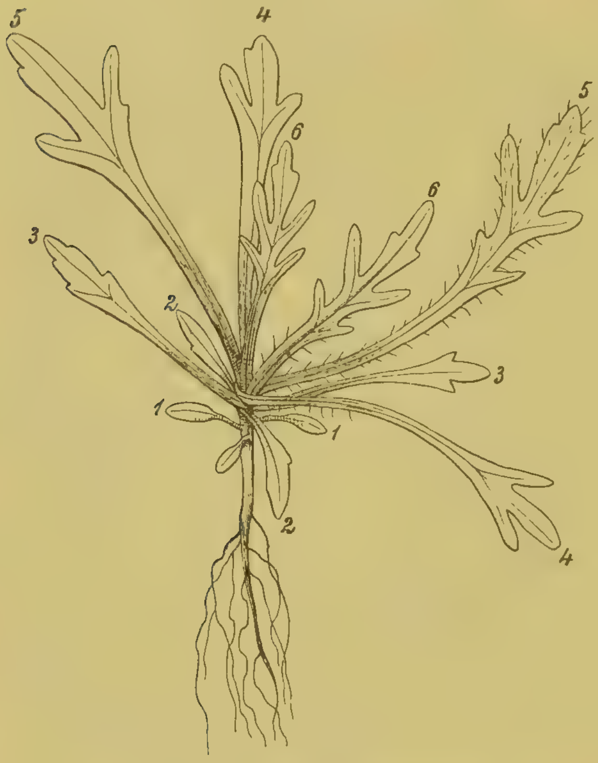

Fig. 596.—*Ajuga Chamæpitys.*
Nat. size.

Second pair lanceolate, obtuse, tapering somewhat to both ends with generally a small tooth on each side.

Third pair similar to the second but larger, with a deeper blunt tooth on each side, trinerved.

Fourth pair narrowly cuneate, deeply trifid, with oblong, obtuse lobes, trinerved.

Fifth pair rather unequal, one leaf pinnatifid with four oblong, obtuse lobes and a larger terminal one; the other leaf deeply trifid.

Sixth pair narrowly oblong, pinnatifid, with linear-oblong, obtuse segments, the terminal one larger and one- to two-toothed.

PLANTAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1223.

Fruit and Seed.—The ovary is superior and syncarpous, consisting of two carpels united to form two cells, or by the development of spurious septa it becomes imperfectly three- to four-celled; in monœcious species it is one-celled. The ovules are solitary, or vary from two to fourteen in each cell in different species, amphitropous, and attached ventrally to axile placentas, the solitary ovule in a one-celled ovary is basal. The fruit is small, included in the persistent calyx, two-celled, two- to many-seeded and dehisces circumscissly below the middle, at, or near the base; when one-seeded it is indehiscent. The seed is peltate and attached by or near the middle to axile placentas or to a basal placenta. The testa is mucilaginous, and swells up in water. Fleshy endosperm is present in variable quantity according to the species. The embryo is generally large and straight, rarely curved, parallel to the hilum, and in one-seeded fruits is erect or transverse. The cotyledons vary in being ovate, oblong or linear, with their backs or edges to the placentas in different species. The radicle is generally and sometimes considerably narrower than the cotyledons, equal in length or more often shorter and inferior. The seeds observed may be conveniently divided into those having the backs and those having the edges of the cotyledons to the axis. The first group is represented by Plantago media (fig. 597) which has small, oval, peltate, plano-convex or subconcavo-convex seeds attached to axile placentas. The hilum is below the middle of the ventral face of the seed. The embryo generally lies across the seed diagonally, or oblique to the median axis, and has oblong-spathulate cotyledons lying in the broader plane of the seed with their backs to the hilum or placenta. The radicle is short. The fruit is two-celled and four-seeded. P. major has two-celled and eight-seeded fruits with smaller seeds; but the embryo is similarly disposed to that of P. media. The cotyledons of P. major are oblong and much wider than the terete radicle.

The varieties of this species, namely P. m. intermedia and P. m. asiatica, conform to the type.

Other species have the cotyledons with their edges to the axis, or placenta of the fruit, as for instance P. lanceolata (fig. 600). The ovary is two-celled and four-ovuled, but the fruit bears only one perfect seed in each cell. The seed is comparatively large, occupies the whole of the cell, and is oblong, peltate and deeply concave on the ventral face. The embryo is nearly as long as the endosperm and straight. The cotyledons are linear, semiterete in transverse section, lying in the narrow way of the seed; they almost equal the endosperm in thickness, and have their edges to the placenta. The radicle is shorter and narrower. The object of this arrangement of the cotyledons seems to be for the greater convenience of exit from the seed during germination, because if they had been placed in the broader plane of the seed they might become too wide or even be curved in conformity with the incurving of the sides of the same, when it would be impossible for them to get out. In P. media, for instance, where the seeds are nearly flat, the latter do not split open during germination, but the embryo escapes by an opening at one end. In P. stricta it closely resembles that of P. lanceolata. The fruit of P. Cynops is two-celled with one seed in each cell. The seed is ovate, peltate, concave on the ventral face, and has a large suborbicular hilum below the middle of that aspect. The cotyledons are thicker than wide, but their arrangement is precisely that of P. lanceolata. The seeds of P. arenaria are also solitary in each cell and agree with those of P. Cynops in every respect.

Some species whose cotyledons lie in the narrow plane of the seed differ in certain respects from those above mentioned. The seed is not concave on the ventral aspect, but may either be biconvex or plano-convex, and the embryo is relatively very large. P. Coronopus is an instance of the former. The seed is broadly oblong with a small hilum below the middle of the ventral face, and is elliptic in transverse section. The cotyledons are linear, as thick as they are wide, and more than semiterete in transverse section, conforming pretty closely to the outline of the seed. The radicle is short and turbinate. The fruit is two-celled and many-seeded. P. maritima differs from the above by having a two-celled, two-seeded fruit, and plano-convex seeds. Endosperm is relatively scanty, and the embryo occupies the greater portion of the seed. In other respects it is similar to P. Coronopus.

In comparing P. media and P. Coronopus, I find that although the cotyledons of the embryos are differently placed with regard to the placentas, they are most conveniently situated in each case to occupy the greatest amount of the area of the seed and more especially during germination. The cotyledons of P. media are thin, wide and placed in the broad way of the seed so that they can readily grow wider during germination and also utilise the endosperm around them. The cotyledons of P. Coronopus have their edges to the placentas, and their width compared with the combined thickness of the two is as two to three, so that they really occupy a greater area of the seed than if they had their backs to the axis. This is even more evident in P. maritima.

Seedlings.—Just as there are two leading types of seeds, so are there two distinct types of seedlings with their characteristic cotyledons. The broad general distinction which I adduce from the seedlings coming under my observation is that species with broad many-ribbed leaves have flat, spathulate or lanceolate, but not necessarily very broad cotyledons; while those with narrow leaves, whether entire or divided, have linear and thick succulent cotyledons.

The thin or flat type is represented by Plantago media (fig. 598) which has linear-spathulate or lanceolate cotyledons tipped with a dark spot or minutely emarginate, and one-nerved. One or both cotyledons are liable to fission, so that they may be emarginate, bifid or bipartite, sometimes appearing as three or four instead of the normal two. This takes place as a result of growth during germination, and appears to facilitate their exit from the seed. The first leaf is one-nerved; the second trinerved at the base; and the third and fourth are trinerved nearly to the apex. All four are spathulate and hairy. The ultimate leaves are ovate and seven- to nine-nerved. P. major belongs to this type.

The second group is represented by P. Coronopus (fig. 599) which has linear, entire, semiterete, thinly pilose cotyledons about 8 mm. long and slightly connate at the base. The first six leaves are similar but larger, longer, and more hairy. The ultimate ones are long, lanceolate, pinnatisect, with linear or lanceolate, pinnatifid or toothed segments, and are trinerved in the lower part, giving off lateral nerves to the segments.

The cotyledons ultimately become succulent and nearly terete. Those of P. arenaria differ chiefly in their greater length, measuring from 2–2·6 cm. The leaves are all linear, acute, hairy or pilose, slightly furrowed along the middle, entire, and differ from the cotyledons chiefly in size. The cotyledons of P. gnaphalioides conform to those of P. arenaria both in shape and size. The leaves are opposite and the first pair resemble the cotyledons. The second pair have one to two obsolete teeth on each side, and the third to the seventh pairs inclusive are linear, broadest above the middle, and obsoletely glandular-dentate. The cotyledons of P. callosa vary from 2·8–3·7 cm. in length, and are glabrous, succulent and terete, but otherwise conform to the type. The leaves are linear, entire and alternate. The first one is thinly pilose; the second is larger and slightly furrowed along the middle; the third and fourth are deeply furrowed above and tomentose, followed by two which are broader, deeply channelled above and carinate beneath. The ultimate ones are felted with tomentum and hoary.

Plantago media, *L.* (fig. 597).

Ovary two-celled, four-ovuled; ovules peltate, amphitropous; micropyle inferior.

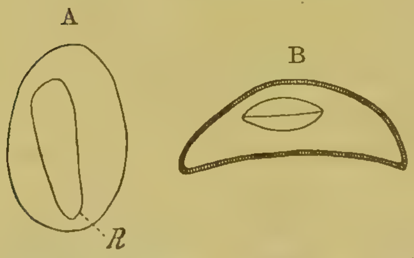

Fig. 597.—*Plantago media.* A, longitudinal section of seed, × 8: *R*, radicle. B, transverse section of seed, × 16.

Fruit capsular, dry, membranous, two-celled, two- to four-seeded, dehiscing circumscissly.

Seeds plano-convex or sub-concavo-convex, peltate, small, oval in longitudinal outline, with equal obtuse ends, or the basal end slightly broader; testa thin, pale brown; hilum a little below the middle on the ventral aspect, round, deeper brown than the rest of the testa; raphe tapering obliquely from the hilum towards the upper end of the seed.

Endosperm copious, fleshy, white.

Embryo straight, narrow, colourless, a little shorter than the endosperm and embedded in it a little nearer the dorsal aspect of the seed and somewhat oblique to its median axis; cotyledons oblong-spathulate, plano-convex, tapering towards the base, obtuse, entire; radicle inferior, obtuse, shorter than the cotyledons.

Seedling (fig. 598).

Primary root slender, tapering, fibrous.

Hypocotyl tapering downwards, ·5–1·4 cm. long, glabrous, pale green.

Cotyledons linear-spathulate, or lanceolate, obtuse, tipped with a dark spot or minutely emarginate, tapering into the petiole, glabrous, light green, with a distinct midrib and obscurely reticulate, 1·1 cm. long including the petiole, 2·75 mm. wide, above the middle.

Out of a batch of eight seedlings two had one of the cotyledons more or less deeply bifid or bipartite.

Stem very short, constituting the persistent rhizome.

Leaves simple, radical, alternate, exstipulate, petiolate, hairy on both surfaces, longitudinally five- to seven- or more -nerved, subplicate longitudinally, and obscurely reticulate between the nerves, light green; petioles broad, more or less winged in the old plant, dilated and sheathing at the base, broadly and shallowly channelled above.

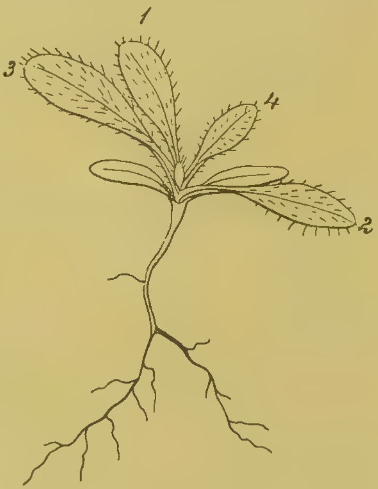

Fig. 598.—*Plantago media.* Nat. size.

No. 1. Spathulate, obtuse, entire, with a distinct midrib, and obscurely reticulate.

No. 2. Similar, but showing three nerves in the petiole.

Nos. 3 and 4. Similar, but having three nerves extending nearly to the apex.

Ultimate leaves ovate, with short petioles or oval-elliptic, more or less considerably drawn out at the base, five- to seven- or more nerved longitudinally, plicate, obtuse, distantly and obscurely dentate on the sides.

Germination.—In eight days fourteen seedlings germinated, and twelve (a percentage of 85·7) carried the testa up with the cotyledons.

Out of thirty-six seedlings that germinated, one had the one cotyledon entire and the other bipartite, i.e. the seedling had apparently three cotyledons, while another seedling had four such cotyledons. This gives an average of 5·5 per cent. of seedlings with cut or divided cotyledons, but the average might possibly be much greater in a large batch.

Plantago major, *L.*

Capsule two-celled, eight-seeded, ovoid, obtuse, mucronate, glabrous, dehiscing circumscissly about the middle.

Seed peltate, oblong, obtuse at either end, variously angled by mutual pressure, convex on both surfaces, especially on the back, smooth, minutely wrinkled or striated, pale green, becoming brownish-green, ultimately black or nearly so; hilum oval, ventral, inconspicuous; micropyle and radicle inferior.

Endosperm copious, fleshy, or somewhat horny when dry, colourless.

Embryo very similar to that of P. media.

Plantago Coronopus, *L.*

Ovary two-celled, many-ovuled; ovules attached below their middle.

Capsule ovoid or oblong-fusiform, two-celled, many-seeded, dehiscing circumscissly.

Seed oblong-oval, suddenly tapered to an obtuse point at the lower end, small, pale brown, generally suffused with a glaucous colour, dorsally compressed and obtusely ancipitous; hilum forming a round, darker-coloured mark on the ventral aspect below the middle of the seed; raphe and chalaza inconspicuous; micropyle at the lower and obtusely pointed end of the seed.

Endosperm in the mature seed moderately copious, fleshy, dirty white.

Embryo comparatively large, straight, central, nearly equalling the endosperm in length, dirty white or pale brown in colour; cotyledons linear, obtuse, entire, plano-convex, thick and semiterete or even thicker, lying in the narrow way of the seed with their edges to the placenta (the thickening occurring in the broader way of the seed); radicle turbinate, obtusely pointed, much shorter than the cotyledons, lying in the lower pointed end of the seed.

Seedling (fig. 599).

Primary root tapering, with numerous lateral fibres.

Hypocotyl short, mostly subterranean, tapering into the root.

Cotyledons linear, obtuse or subacute, with hyaline bristle-like hairs, about 8 mm. long.

Stem herbaceous, with undeveloped internodes.

Leaves simple, radical, alternate, exstipulate, petiolate in the adult stage, coarsely hairy all over with whitish bristle-like hairs, trinerved in the adult stage, the nerves branching into the primary divisions of the leaf; petiole indistinguishable from the leaf in the seedling stage, trinerved and grooved in the adult, hairy, dilated and sheathing at the base.

Primary leaves linear, similar to but larger and longer than the cotyledons.

Ultimate leaves lanceolate, entire or more or less deeply pinnatifid; segments oblong, linear or lanceolate, acute, entire or slightly toothed or lobed.

Germination.—The seeds germinated in three days.

The radicle is first protruded and soon establishes itself in the ground, sending out root-hairs.

The hypocotyl then emerges, and together with the basal part of the cotyledons forms an arch by which (using the radicle as a fulcrum or holdfast) the upper parts of the cotyledons are pulled out.

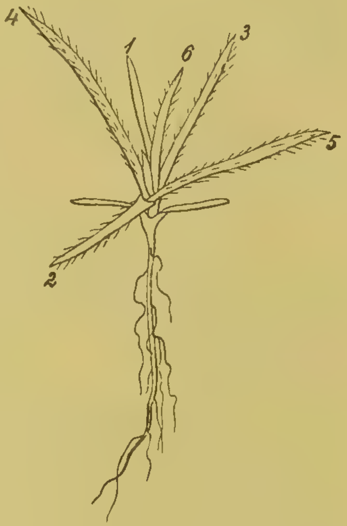

Fig. 599.—*Plantago Coronopus.* Nat. size.

The epithelial cells of the seed become mucilaginous in the presence of moisture, and attaching themselves firmly to the soil retain the testa there while the cotyledons are being pulled out. The testa is rarely pulled out of the ground.

The cotyledons emerge from the seed with their edges upward; they are at first closely applied face to face, but gradually diverge and open, and turn their faces upwards to the light, while the tips retain the curve for a considerable time.

Plantago arenaria, *W. et Kit.*

Ovary two-celled, with one peltate, amphitropous ovule in each cell, attached in a depression of the thickened placenta about half way between the base and apex of the cell.

Capsule ovoid, dehiscing circumscissly about the middle, two-celled, two-seeded, glabrous.

Seed oblong or ovate-oblong, tapering slightly upwards but blunt at either end, concave or boat-shaped on the ventral face, pale green when immature, becoming deep shining brown, and always semi-transparent, disclosing the embryo ; hilum about the middle of the ventral aspect, oval, whitish ; micropyle and radicle inferior.

Embryo straight, colourless, falling a little short of the endosperm transversely to the axis; cotyledons linear, obtuse, entire, tapering to the base and appearing slightly petiolate, closely applied face to face with their edges to the placenta ; radicle tapering to an obtuse point, thinner and shorter than the cotyledons, but lying in the broader and lower end of the seed.

Endosperm abundant, fleshy, somewhat horny when dry, subtransparent, whitish.

Seedling.

Primary root descending, sending off numerous lateral fibres.

Hypocotyl terete, pubescent, 1·2–1·6 cm. long.

Cotyledons long, linear, cylindrical or subterete, acute, entire, sessile, with a few scattered minute hairs, green, without any apparent venation.

Stem with primary internodes undeveloped.

First leaves simple, entire, opposite, radical, linear-acute, slightly furrowed, hairy, green, one-nerved, sessile, exstipulate.

Plantago Cynops, *L.*

Ovary as in P. arenaria.

Capsule broadly ovoid, mucronate, glabrous, pale green, with a pale line where the two carpels come together, and a dark, slender one along the middle of the carpel giving the capsule in a young state the appearance of consisting of four carpels, two-celled, two-seeded, dehiscing circumscissly near the base.

Seed ovate, obtuse, peltate, much compressed dorsally, but convex in conformity with the inner surface of the capsule, concave on the ventral face, smooth, shining, deep green when young with sufficient transparency to show the embryo by transmitted light ; hilum ventral, large, broadly oval or suborbicular, slightly below the middle of the seed ; radicle and micropyle inferior.

Endosperm copious, fleshy, rather transparent.

Embryo very similar to that of P. arenaria.

Plantago gnaphalioides, *Nutt.*

Hypocotyl very similar to last species, glandular-pubescent.

Cotyledons as in last species ; slightly connate at the base, with a thin glandular pubescence, 2–2·5 cm. long.

Stem annual, terete, erect, glandular-pubescent; 1st internode 1·7–2·6 cm. long; 2nd similar, or somewhat shorter.

Leaves cauline, opposite, decussate, tapering to the base, sessile, and slightly connate, with an indistinct midrib, glandular-pubescent, exstipulate.

First pair linear, slender, similar to the cotyledons.

Second pair linear, obtuse, entire, or with one or two obsolete teeth on each side.

Third to seventh pairs linear, broadest above the middle, distantly and obsoletely dentate, teeth glandular.

Plantago callosa, *Coll.*

Primary root very long, flexuose, wiry, annual.

Hypocotyl erect, terete, glabrous, deep purple or red, 1·8–2·8 cm. long.

Cotyledons linear, acute, terete, glabrous, sessile and connate at the base, forming a cup surrounding the rosette of leaves, 2·8–3·7 cm. long.

Stem with the internodes undeveloped.

Leaves simple, entire, radical, alternate, sessile, clasping at the base, hoary or felted with a white tomentum.

No. 1. Linear, semiterete, flattened above, very thinly hairy, or pilose.

No. 2. Larger and shallowly channelled above.

Nos. 3 and 4. Tomentose and deeply furrowed above.

Nos. 5 and 6. Broader, tomentose, with a wide deep channel above, and obtusely carinate beneath.

Plantago lanceolata, *L.* (fig. 600).

Ovary two-celled, with axile placentation bearing about midway between the base and apex of each cell two amphitropous ovules; micropyle inferior.

Capsule oblong, obtuse at either end, glabrous, two-celled with one perfect seed in each cell, dehiscing circumscissly about one-third above the base.

Seed oblong, obtuse at either end, peltate, equalling the interior of the cell in length and breadth, concave on the ventral face and appearing boatshaped, smooth, pale green in the immature state, then becoming colourless or pale yellow and subtransparent, afterwards deep shining brown and still semitransparent when fresh, ultimately deep brown; hilum oval, forming a white or pale spot on the ventral aspect about or a little below the middle; micropyle and radicle inferior.

Endosperm abundant, fleshy or somewhat horny when dry, subtransparent.

Embryo straight, colourless, embedded in endosperm and falling a little short of the length of the seed; cotyledons narrowly oblong or linear, obtuse, plano-convex, closely applied face to face transversely to the axis, but in the narrow way of the seed, with their edges to the placenta and towards the dorsal and ventral face of the seed, shortly petiolate or tapered downwards; radicle oblong, obtuse, shorter and considerably narrower than the cotyledons, inferior, tapering downwards.

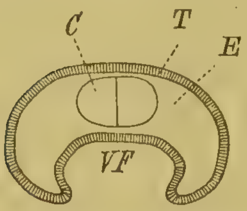

FIG. 600.—*Plantago lanceolata*, × 12. Transverse section of seed: *C*, cotyledon; *T*, testa; *E*, endosperm; *VF*, ventral face.

Plantago stricta, *Schousb.*, is very similar to P. lanceolata.

Plantago maritima, *L.*

Ovary two-celled, with one ovule in each cell.

Capsule narrowly ovoid, two-celled, two-seeded, dehiscing circumscissly about one-third from the base; the upper part carrying with it the placentas and seed.

Seed oblong-lanceolate, biconvex, or slightly flattened on the ventral face.

Embryo straight, large, and nearly occupying the whole of the interior of the seed; cotyledons with their edges to the axis.

NYCTAGINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1.

Fruit and Seed.—The superior ovary is included in the tube of the perianth, and is one-celled with a solitary, basal, erect, campylotropous ovule. The fruit is a thin, membranous and indehiscent utricle, enclosed in the base of the persistent and now leathery, fleshy or hardened perianth which is termed the anthocarp. The latter is ribbed, furrowed, angled or winged, sometimes mucilaginous, sometimes garnished with stalked glands. The pericarp is sometimes thin and leathery or fleshy. The seed is erect and has a thin hyaline testa, or the latter may be wholly amalgamated with the pericarp. Endosperm is copious, farinaceous, fleshy or mucous, or scanty, and sometimes almost wanting. The embryo is sometimes straight with broad, foliaceous, conduplicate cotyledons surrounding or enclosing the endosperm, with a short inferior radicle; in other cases it is doubled upon itself with broad, foliaceous, incumbent and convolute cotyledons wrapped round the endosperm; or the cotyledons are narrow and closely applied to the latter. When the embryo is doubled upon itself, the radicle is long, and external to the endosperm, with its tip close to the inferior basal micropyle.

An unusual character occurs in Cryptocarpus which has an annular embryo; and in Abronia one of the cotyledons is small and almost aborted.

Two different types of embryo occur amongst the seeds observed. The cotyledons are always unequal, but in some cases one is nearly aborted. The anthocarp of Mirabilis longiflora is obovoid, closed by constriction above the true fruit, hardened or crustaceous and sculptured on the outer surface. The pericarp is thin and membranous as is the testa which adheres to it. The embryo is doubled upon itself with unequal, concave cotyledons occupying the periphery of the seed and enclosing the farinaceous endosperm. The radicle is long, terete, stout and occupies the other side of the seed, and together with the outer cotyledon determines the smaller size of the inner cotyledon by restricting its growth. The anthocarp of Oxybaphus nyctagineus is oblong, obtusely five-angled, hairy and closely invests the fruit, and that again the seed which conforms to the interior. The outer cotyledon is very broad, almost oblate and surrounds the endosperm with its edges closely abutting against the radicle. The inner and smaller cotyledon also comes close up against the radicle with its edges. In other respects this species resembles Mirabilis longiflora. The radicle in both cases is curved at its base and longer than the cotyledons.

The second type is represented by Abronia umbellata (fig. 602, B). The anthocarp is strongly five-winged with the wings broadest at the upper end. The ovary and seed are narrowly obovoid or oblong-obovoid, the former slightly oblique at the base where it is attached to the receptacle. The outer cotyledon is broadly ovate-oblong, concave and surrounds the endosperm; the inner one is rudimentary and many times thinner than the petiole of its fellow. The radicle is slightly curved about the middle, longer than the larger cotyledon and occupies the longer side of the seed with its tip occupying the slightly prolonged base. The fruit of A. arenaria is ellipsoid and five-angled. The seed is narrowly obovoid. The other characters (fig. 602, A) correspond to those of A. umbellata. Occasionally, however, a seed may be found containing an embryo, the smaller cotyledon of which is of some considerable size, and nearly half as long as the other.

Seedlings.—As in the seeds so also after germination the cotyledons are unequal. Two leading types may be noticed, namely those which are oblate varying to reniform, and those which vary between oblong and obovate. The more common type of cotyledon is oblate and subtruncate at the base or has a shallow sinus as shown by Mirabilis dichotoma (fig. 601). The cotyledons are five-nerved at the base and reticulate, sometimes emarginate with a tooth in the notch. The lamina of the larger one measures 2·2 cm. long and 4 cm. wide, while the smaller one is about the same length, but only 3·6 cm. wide. The petioles are also unequal. The cotyledons of M. longiflora are trinerved and reticulate, with the midrib forking some distance below the apex, and they are also variously emarginate. The average size of the larger lamina is 2·38 cm. long and 3·25 cm. wide; that of the smaller one is 1·9 cm. long, and 2·76 cm. wide. The petioles are glandular-pubescent and generally unequal in length. In general characters M. multiflora agrees with its congeners. The cotyledons are glabrous and five-nerved; the larger lamina varies in different individuals from 2·4–2·8 cm. long, and 4–4·6 cm. wide; the smaller one is 2·0–2·4 cm. long, and 3·4–3·7 cm. wide.

The seedlings of Oxybaphus agree with the above in general form of the cotyledons, but the latter are notable for the shortness of their petioles. Those of O. viscosus are relatively small, reniform, trinerved, densely pubescent and unequal.

Those of O. ovatus are larger, more decidedly auricled at the base, densely hairy, and sometimes at least unsymmetrical. The first pair of leaves are lanceolate, showing only a midrib, and are hairy like the cotyledons. The latter in O. elegans are more roundly reniform, trinerved, glabrous and, like the others, very shortly petiolate. As in O. ovatus the short hypocotyl becomes fleshy and tuberous at a very early age. The first pair of leaves are lanceolate, succeeded by others which are ovate and glabrous like the cotyledons. A slight variation occurs in O. nyctagineus which has suborbicular, trinerved, glabrous, unequal cotyledons. The lamina of the larger ones measures about 1·5 cm. long, and 1·35 cm. wide, while that of the smaller one is 1·4 cm. long, and 1·3 cm. wide. Both are cuneate at the base.

The species of Abronia differ considerably from the above, both in the form of the cotyledons before and during germination, and in their behaviour afterwards. One of the cotyledons is almost aborted in the seed and remains small for some time after germination but in A. umbellata at least it afterwards becomes the largest and grows like a leaf, attaining the shape of the latter. The lamina of the larger one eight days after germination is oblong, 8–8·5 mm. long, and 4·5–6 mm. wide; twenty-eight days after germination it is still of the same shape, but is 1·4–1·45 cm. long, and 9 mm. wide. The lamina of the smaller one eight days after germination is obovate, 1·25 mm. long, and 1 mm. wide; twenty-eight days after germination it is 1·4–1·8 cm. long, and 8·75–10 mm. wide above the middle. The leaves are alternate, but the primary ones are nearly opposite. The first four are oblong, somewhat cuneate at the base, and rounded at the apex. The full-grown cotyledons of A. arenaria are very unequal. The larger one is oval, 1·4 cm. long, and 8·75 mm. wide, with a petiole 3–4 cm. long, while the smaller one is obovate, 5 mm. long, 3·75 mm. wide, and the petiole 2–2·6 cm. long. The leaves are opposite, but so unequal in size that they appear alternate during development in the bud. They are finely glandular-pubescent, and the first four at least are oval like the larger cotyledon. The ultimate ones are broadly ovate or suborbicular, unequal both in lamina and petiole. This is brought about probably in part by the procumbent or trailing stem interfering with the proper growth of opposite and decussate leaves.

Mirabilis longiflora, *L.*

Hypocotyl short, stout, erect or decumbent, terete, glabrous or glandular-hairy, 1·5–1·8 cm. long.

Cotyledons very like those of M. dichotoma, rather fleshy, frequently emarginate with one or two notches, glabrous except the petioles; midrib strong and prominent on the under side; lamina of the larger cotyledon in an average of four, 2·38 cm. long, 3·25 cm. wide; smaller lamina in an average of four, 1·92 cm. long, 2·76 cm. wide; petioles mostly unequal in length, the longer one belonging to the smaller lamina, semiterete, channelled above, densely glandular-hairy, pale green or reddish, 2·6–5·5 cm. long.

Stem herbaceous, erect at first, ultimately decumbent, ascending or variable; 1st internode 5–5·5 cm. long.

Leaves simple, entire, cauline, opposite, exstipulate, petiolate, irregularly and alternately penninerved and reticulate, with the nerves forking towards the margin of the leaf, and sending a curved branch downwards and the other upwards to meet the one next above it, more or less glandular - pubescent all over, deep dull green above with a reddish midrib, paler beneath and suffused with red; petioles semiterete, channelled above, densely glandular-pubescent.

First pair ovate, obtuse, suddenly tapered into the petiole.

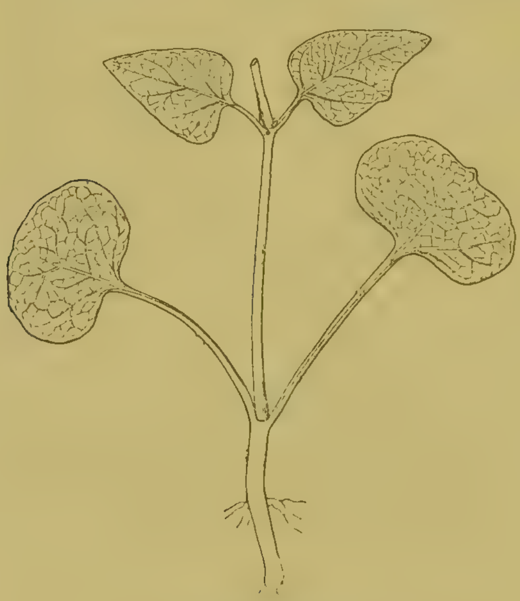

Fig. 601.—*Mirabilis dichotoma.* Half nat. size.

Mirabilis dichotoma, *L.* (fig. 601).

Primary root very short, apparently ceasing to elongate, and like the hypocotyl giving off fibrous lateral rootlets.

Hypocotyl 1·5–2 cm. long, 4 mm. thick, succulent and ultimately becoming fleshy and tuberous, gibbous at the base on one side when young.

Cotyledons unequal, transversely oval, apiculate, subtruncate at the base; the larger one 2·2 cm. long, 4 cm. wide, strongly nerved and reticulate; the smaller one 2·2 cm. long, 3·6 cm. wide; petioles 4·8 cm. and 4·3 cm. long respectively.

Stem erect and forking from the first pair of leaves, terete, glabrous, bright red; 1st internode 6–9·5 cm. long; 2nd (first of the fork) 1·6–3 cm.

Leaves.—First pair ovate, obtuse, irregularly penninerved and reticulate, subtruncate at the base and equal, 3 cm. long and 2 cm. wide; petiole 8–10 mm. long, channelled above, slightly connate at the base.

First pair of the fork ovate, obtuse, constantly very oblique at the base, irregularly penninerved; petiole channelled above, connate at the base, 1–1·5 cm. long.

Second pair of fork triangularly ovate, obtuse, irregularly penninerved and reticulate, pale green on both surfaces; nerves most prominent below; petiole deeply channelled above, convex beneath.

Mirabilis multiflora, *A. Gray.*

Hypocotyl very short or subterranean.

Cotyledons unequal, with long petioles, glabrous, pale subglaucous-green, with an oblate lamina; larger lamina 2·4–2·8 cm. long, by 4–4·6 cm. wide, with five nerves radiating from the base, smaller lamina 2–2·4 cm. long and 3·4–3·7 cm. wide, with a similar venation; petioles semiterete, channelled above, finely glandular-pubescent.

Stem herbaceous, erect, terete, finely glandular-pubescent; 1st internode 4–4·5 cm. long.

Leaves petiolate (upper sessile), ciliate at the margins and pubescent on the nerves beneath, otherwise glabrous, glaucous and suffused with pink; petioles channelled above, finely pubescent.

First pair ovate, obtuse, penninerved, often slightly unequal at the base.

Oxybaphus nyctagineus, *Sweet.*

Hypocotyl very short, subterranean, thickened or tuberous.

Cotyledons suborbicular, obtuse, entire, cuneate at the base, trinerved, with the lateral nerves incurved and uniting with the midrib at its apex, unequal, glabrous, rather persistent; lamina of the smaller one 1·4 cm. long, 1·3 cm. wide, and its petiole shallowly channelled on the upper side, and 1 cm. long; lamina of the larger one 1·5 cm. long, 1·35 cm. wide, with its petiole strongly channelled on the upper side, and 1·15 cm. long.

Stem herbaceous, erect, terete, striate, pubescent, purplish; 1st internode about 1·4 cm. long.

Leaves simple, entire (at least in seedlings), cauline, opposite, exstipulate, petiolate, glabrous, incurvinerved, with two strong lateral nerves proceeding from near the base as in the cotyledons, tapering downwards into the petiole which is grooved above.

First pair obovate, obtuse, entire.

Oxybaphus ovatus, *Vahl.*

Hypocotyl stout, 1–2 mm. long, glabrous, light green, ultimately tuberous and fleshy.

Cotyledons oblate or reniform, unequal, with the larger one unsymmetrical, obtuse, entire, cordate at the base, petiolate, with long thick petioles, hispid, dull green, distinctly pinnatinerved.

Stem erect, terete, pubescent; 1st internode 2–3 mm. long.

First leaves alternate or nearly opposite, lanceolate, subacute, pubescent, reddish-green; midrib alone apparent.

Oxybaphus viscosus, *L'Herit.*

Hypocotyl erect, terete, finely pubescent, reddish, 7–10 mm. long.

Cotyledons very similar to those of O. ovatus, thickly pubescent, greenish above, crimson beneath.

The larger cotyledon is cordate at the base, the smaller one only very slightly so, or not at all.

Oxybaphus elegans, *Chois.*

Hypocotyl as in O. ovatus, 3–5 mm. long.

Cotyledons very similar to those of O. ovatus, very unequal, glabrous, light green, trinerved; petiole flat.

Stem erect, quadangular, herbaceous; 1st internode 1·5–1·8 cm. long; 2nd 1–2·5 cm.

First leaves opposite, decussate.

First pair lanceolate.

Second and succeeding pairs ovate-oblong, obtuse, fleshy, with broad, flat petioles, glabrous, light green above, reddish beneath, distinctly alternately nerved.

Abronia arenaria, *Menz.* (fig. 602, A).

Achene enclosed in and adhering to the ellipsoid, five-angled, persistent base of the perianth.

Seed narrowly obovoid, narrowed to the base, where it is slightly unequal, smooth, pale brown, marked from the base to near the apex on each side with a darker brown line; hilum basal in the notch; micropyle close to it, but occupying the longer lobe of the seed in which the radicle lies.

Endosperm abundant, mealy or farinaceous, white, lying in the centre of the seed and surrounded, except between the cotyledons and radicle, by the embryo.

Embryo large, much curved or doubled upon itself, outside the endosperm, colourless; cotyledons very unequal; the outer one concave or scoop-shaped, lying round the outside of the endosperm which it grasps in its inner concave face, equal in length to the seed; the inner reduced to a small elevation at the base of the petiole of the large one; radicle cylindrical, lying on the outside of the endosperm on the opposite side of it from the cotyledon, slightly tapered to an obtuse tip, pointing to and close to the micropyle, equalling the length of the seed and somewhat longer than the large cotyledon. The smaller cotyledon, however, varies a little in size.

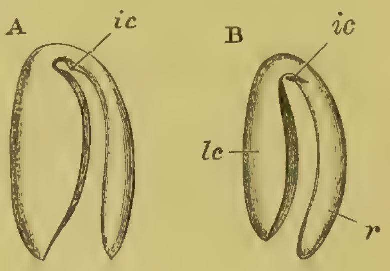

FIG. 602.—A, *Abronia arenaria.* Embryo: *ic*, rudimentary cotyledon, × 6. B, *Abroma umbellata.* Embryo, × 6: *lc*, larger cotyledon; *ic*, rudimentary cotyledon; *r*, radicle.

Seedling.

Primary root tapering downwards, flexuose, giving off a few lateral rootlets, and growing through the remains of the fruit and anthocarp.

Hypocotyl decumbent, thickened towards base of cotyledons, glandular-pubescent, 1·2–2·2 cm. long.

Cotyledons very unequal in size of lamina and length of petiole, glandular-pubescent, fleshy; lamina of larger one obovate or oval, 1·4 cm. long, 8·75 mm. wide; petiole 3–4 cm. long; lamina of smaller one obovate, 5 mm. long, 3·75 mm. wide; petiole 2–2·6 cm. long.

Stem herbaceous, decumbent or spreading on the ground, densely glandular-pubescent, subsucculent, thickening slightly beneath the nodes, pale green or suffused with red, or flesh-coloured; 1st internode 3·2 cm. long; 2nd 9 mm.

Leaves cauline, simple, entire, opposite, unequal, exstipulate, petiolate, glandular-pubescent and deep green above, somewhat paler beneath and densely glandular-pubescent, viscid, penninerved with the ascending nerves prominent beneath, or three- to five-nerved from the base in the lower half of the leaf; petioles semiterete, flattened or subconvex on the upper surface, gradually tapering upwards, channelled at the insertion of the lamina, densely glandular-pubescent, viscid, fleshy.

First pair small, unequal; one obovate, the other similar but wider.

Second pair unequally developed; large one oval, obtuse, with a lamina 2·3 cm. long, 1·7 cm. wide, and a petiole 4·8 cm. long; smaller leaf rotund, concave, 9 mm. in diameter with a petiole 3 mm. long.

Ultimate leaves opposite, distichous, and all turned to the upper side of the prostrate stem, developing unequally from the bud and always with laminæ of a different shape the one from the other, and petioles of unequal length; smaller leaves rotund, slightly cuneate at the base, trinerved in the lower half and arranged alternately; larger broadly ovate, rounded at the end, less frequently broadly oval, obtuse, three- to five-nerved in the lower half, and also alternate.

Abronia umbellata, *Lam.* (fig. 602, B).

Achene small, narrowly obovoid, slightly compressed on one side, glabrous, shining, straw-coloured with a brown line running along each side for the greater part of its length, corresponding to the curvature of the ovule; anthocarp five-winged with the wings broadening upwards and tapering cuneately to the base, glabrous; wings nerved and subreticulated transversely.

Seed pale-coloured or white; testa thin, membranous; chalaza, hilum and micropyle contiguous, basal; raphe none.

Endosperm rather copious, farinaceous, white, forming a mass occupying the centre of the seed.

Embryo as in A. arenaria.

Seedling.[1]

Primary root very little or altogether unbranched in the early stages.

Hypocotyl erect or curved, or decumbent, terete, pale green or pinkish, or reddish, stout, shortly glandular-pubescent, 1–1·8 cm. long, produced into a footlike process at the base on one side, which probably assists in keeping down the fruit while the germinating embryo makes its exit.

Cotyledons very unequal immediately and for a considerable time after germination, dull green, shortly glandular-pubescent; lamina of larger one eight days after germination oblong, 8–8·5 mm. long, 4·5–6 mm. wide, and twenty-eight days after germination oblong, 1·4–1·45 cm. long and 9 mm. wide; lamina of the smaller one eight days after germination obovate, 1·25 mm. long, 1 mm. wide, sessile or subsessile, and twenty-eight days after germination obovate, tapering to the base, 1·4–1·8 cm. long and ·8·75–10 mm. wide above the middle; petiole of the larger one eight days after germination 5·25–12·5 mm. long, and twenty-eight days after germination 2·4–2·8 cm. long, semiterete, flattened on the upper side; petiole of the smaller one eight days after germination very small or almost absent, but twenty-eight days after germination 2·5–3 cm. long, terete, and slightly channelled at the apex only.

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[1] Figured by Darwin in *Movement of Plants*, p. 95.

The larger cotyledon eight days after germination exhibits a distinct midrib and two lateral nerves near the base, but twenty-eight days after germination the cotyledon becomes rather fleshy, and has the midrib only discernible; the smaller cotyledon at first exhibits a midrib only, and that very indistinctly, but twenty-eight days after germination it is obovate, tapered to the base and trinerved, about the same size as the originally large cotyledon or larger, with a longer or shorter petiole. In all these characters it seems to behave like a true leaf, but maintains the position of a cotyledon.

Fifty-six days after germination the originally large cotyledon measured as follows:—Petiole 2·7 cm. long, with the lamina 1·85 cm. long, 1·1 cm. wide; the originally small one now the largest, with a lamina 2·3 cm. long, 1·2 cm. wide, and its petiole 4·9 cm. long, faintly trinerved.

Stem herbaceous, annual, erect at first, ultimately procumbent; primary internodes undeveloped or very little developed in the early stage, but afterwards the first one elongates in different individuals from 5–18 mm.

Leaves radical and cauline, alternate, or primary ones almost opposite, shortly and densely glandular-pubescent, alternately and ascendingly penninerved, rather fleshy, with the smaller nerves indistinct or altogether indiscernible; petioles terete, tapering somewhat upwards, densely and shortly glandular-pubescent.

No. 1. Oblong, obtuse, entire, suddenly tapered into the petiole, with about two alternate, indistinct nerves on each side of the midrib, best seen on the under surface.

Nos. 2 and 3. Similar, but somewhat larger with three to four nerves on each side of midrib.

No. 4. Similar, with four to five nerves on each side of midrib.

ILLECEBRACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 12.

Fruit and Seed.—The ovary is superior, ovoid, or globose, one-celled, with sometimes a slender thread running through it, and contains one, rarely two amphitropous, anatropous, or semi-anatropous ovules, which are erect, pendulous, or inverted and suspended from a basal funicle. The fruit is a utricle enclosed in the perianth, and is rarely nut-like, crustaceous, membranous, indehiscent, or torn at the base, and one-seeded. The seed is erect or inverted, ovoid, clavate, orbicular or lenticular. The testa is thinly membranous, without an aril, enclosing a mealy or fleshy, copious or scanty endosperm. The embryo is sometimes annular surrounding the endosperm and has narrow cotyledons. The radicle is elongated and incumbent, superior or inferior, sometimes dorsal and club-shaped, straight or slightly incurved and closely applied to the oblong cotyledons.

The fruit of Corrigiola is a nut with a crustaceous pericarp, and is globose or ovoid-trigonous. The cotyledons are narrow, and the radicle is superior. In Achyronychia, Habrosia, and Pollichia the ovary contains two or four ovules.

The fruit of Herniaria is one-celled and one-seeded. The seed is roundly obovoid or almost globular, basal, erect, and anatropous or subanatropous. The embryo (fig. 605) is peripheral to the endosperm and curved round one side of the seed and across the top where the cotyledons form a sort of a hook. The cotyledons are linear, semiterete, about the same breadth and length as the radicle, and lie in the narrow plane of the seed with their backs facing the hilum. The ovule of Scleranthus annuus is also solitary but campylotropous and suspended from a filiform basal funicle with the hilum and micropyle superior. The embryo is peripheral lying in the narrow way of the seed which it almost entirely surrounds, with a short superior radicle and linear, semiterete incumbent cotyledons facing the basal placenta. The cotyledons are slightly broader than the radicle and about twice as long. The seed and fruit are ovoid and conform to the interior of the urceolate hardened perianth-tube which is surmounted by the four- to five-lobed lamina.

Seedlings.—As the seeds are small the seedlings arising from them are also small and the cotyledons of simple types. Two distinct forms have come under my notice, namely linear-oblong and broadly ovate cotyledons. Those of Illecebrum verticillatum (fig. 603) are linear-oblong and tapered to the base where they are slightly connate. The leaves are opposite and the first three pairs linear-spathulate and tapered to the base like the cotyledons, which they resemble, except that they are wider at the apical end. The cotyledons of Herniaria hirsuta (fig. 606) are twice or three times as long, more decidedly petiolate, and show an obscure midrib, but otherwise conform to the above type. The persistent perianth-tube is hairy externally, and serves by that means to retain itself in the ground, thus holding down the fruit and testa of the seed while the embryo is able to get clear. In a few cases, however, if these investments have not been fairly well covered with soil, they are carried up on the cotyledons during germination. The cotyledons are sessile at first and gradually develop short petioles by subsequent growth. When the fruit and seed are carried up, the cotyledons make their exit at first by the mere act of lengthening, then one gets perfectly clear by spreading out to the light, while the other carries the empty husks for some time. A somewhat similar process takes place in Scleranthus annuus where the cotyledons are similar in shape to those of Illecebrum verticillatum, but are more strictly linear and one-nerved. In Paronychia dichotoma (fig. 604) the cotyledons are broadly ovate. They are distinctly petiolate, without discernible venation and measure 2·5 mm. in length, and 2 mm. in width. The leaves are opposite, glabrous, and the two first pairs are oval or elliptic and

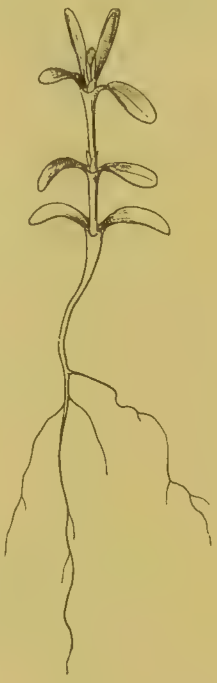
FIG. 603.
Illecebrum. verticillatum, × 3.

taper into a petiole which is slightly connate at the base. They therefore correspond to the cotyledons in being broad, just as both sets of organs are relatively narrow in the above-mentioned species.

Illecebrum verticillatum, *L.* (fig. 603).

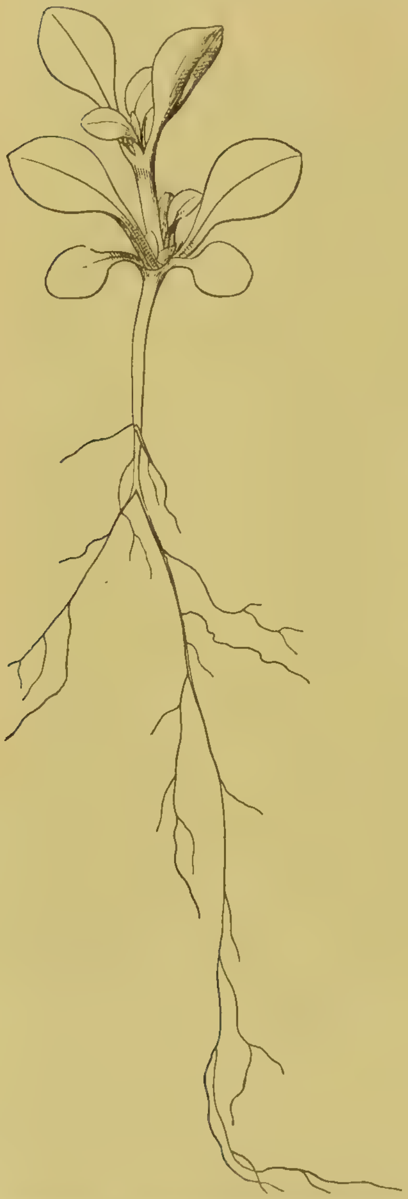

FIG. 604.—*Paronychia dichotoma*, × 3.

Primary root slender, fibrous, annual.

Hypocotyl erect, ultimately procumbent, tapering downwards, glabrous, pale green or stained red, 3-5 mm. long.

Cotyledons linear-oblong, obtuse, entire, sessile, tapering to thé base and slightly connate, glabrous, light green, 2·25–2·75 mm. long.

Stem erect, soon becoming prostrate, annual, slender, terete, leafy, glabrous, pale green; 1st internode 2·5–3 mm. long; 2nd 2·5–3·5 mm.

Leaves simple, entire, cauline, opposite and verticillate, stipulate, sessile, glabrous, narrowed to the base, with an indistinct midrib, slightly connate; stipules small, scarious, more or less united and sheathing the stem, in the axils of the leaves, but interpetiolar in their insertion.

First, second and third pairs linear-spathulate, obtuse, tapering much to the base.

Paronychia dichotoma, *Nutt.* (fig. 604).

Primary root very slender, long, tapering, with fibrous lateral rootlets.

Hypocotyl erect, terete, glabrous, but scabrous or covered with numerous minute crystalline excrescences, short and tapering indistinguishably into the radicle.

Cotyledons broadly ovate or rotund-ovate, obtuse, entire, glabrous, deep green, opaque, without any distinguishable midrib or other nerves; lamina 2·5 mm. long, 2 mm. wide; petiole flattened above or slightly grooved, scabrous on the midrib beneath, 1 mm. long, connate at the base.

Stem annual, erect, terete, glabrous, pale green; 1st internode undeveloped; 2nd 1–2·5 mm. long.

Leaves simple, entire, radical and cauline, opposite, stipulate, petiolate, glabrous, dark opaque green; petiole flattened above, scabrous on the midrib beneath, subconnate at the base; stipules interpetiolar, scarious, small, united in pairs.

First and second pairs oval or elliptic, obtuse.

Herniaria hirsuta, *L.* (fig. 605).

Ovary one-celled, one-ovuled; ovule basal, erect, anatropous; radicle inferior.

Fruit an achene, or utricle, somewhat obovoid, laterally compressed, glabrous, pale-coloured, tipped with the short persistent style and stigma, enclosed in the persistent, comparatively large, hairy calyx, one-celled, one-seeded, indehiscent.

Seed erect on a basal funicle, obovate-rotund or almost orbicular, laterally compressed, very minute, glabrous, black, shining; testa crustaceous, comparatively thick; hilum close to the base and oblique; raphe and chalaza inconspicuous; micropyle basal and contiguous to the hilum.

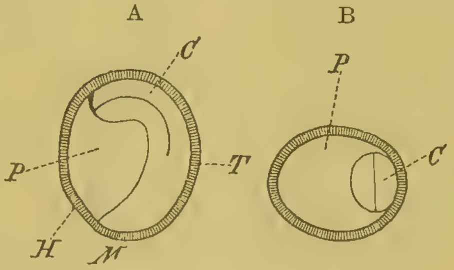

FIG. 605.—*Herniaria hirsuta*, × 30.
A, longitudinal section of seed. B, transverse section of seed: *P*, endosperm; *H*, hilum; *M*, micropyle; *T*, testa; *C*, cotyledon.

Endosperm farinaceous, pale, subtransparent white, confined to a space between the embryo and that side of the seed on which is the hilum.

Embryo comparatively large, curved round one side of the seed, outside the endosperm, and across the upper end, colourless; cotyledons linear, obtuse, entire, plano-convex or semiterete, lying in the narrow plane of the seed with their backs to the axis or the hilum, not broader than the radicle, curved; radicle terete, less curved than the cotyledons, and equal to them or slightly shorter, suddenly narrowed to an obtuse point.

Germination.—The solitary seed is retained in the achene, and that again in the perianth when the whole falls to the ground at maturity. The hairy perianth serves to retain the fruit in the ground during germination so that the cotyledons are able in most cases to pull themselves out, clear of everything. When the seed has been rubbed out of the perianth before sowing, the testa is usually carried up. If this happens the cotyledons are then left to their own resources in making their exit, and by growth in length are able to push themselves out and then spreading open to receive the light; the testa is often carried away on one cotyledon. The testa splits vertically a little way, and although it gapes somewhat it continues to hold on to the tip of the cotyledon for some time.

Seedling (fig. 606).

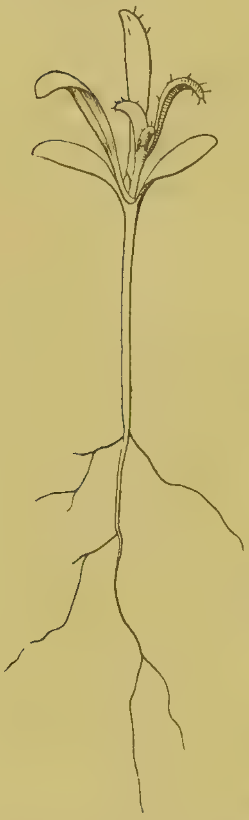

FIG. 606.
Herniaria hirsuta, × 2.

Primary root tapering, fibrous, normal.

Hypocotyl erect, terete, glabrous, almost colourless, 1·2–1·6 cm. long.

Cotyledons at first lanceolate-oblong, obtuse, entire, glabrous, somewhat convex above and curved or arched, light green, sessile on germination and 1·25 mm. long, ultimately oblong-linear from 3·5–8 mm. long, 1·25 mm. wide, and shortly petiolate.

Stem herbaceous, procumbent, terete, scabrous or rough with little points; 1st internode undeveloped; 2nd short, 1–5 mm. long.

Leaves simple, entire, radical and cauline, opposite, stipulate, petiolate, with an indistinct midrib best seen on the under side, unequally developed (one in advance of the other); petioles plano-convex or biconvex, short; stipules small, toothlike, scarious, minutely ciliate.

First and second pairs spathulate-linear, obtuse, tapering to the base, rough on the midrib beneath, or raised into little tubercles, more or less hairy.

AMARANTACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 20.

Fruit and Seed.—The ovary is superior, ovoid, ellipsoid, or globose and frequently compressed, one-celled and membranous, rarely coriaceous or fleshy. The ovule is fleshy, solitary except in the tribe Celosieæ where there are two or many, erect or pendulous from a basal funicle and amphitropous. The fruit is a membranous utricle, rarely fleshy, and bursts irregularly or circumscissly. The seed is erect or inverted and suspended from a long funicle, lenticular, oblong or reniform-orbicular and mostly compressed laterally. An aril is sometimes though rarely present. The testa is crustaceous or coriaceous, frequently black or brown or shining. The endosperm is copious, farinaceous and often adheres to the inner and membranous coat of the seed. The embryo is slender and curved round the periphery of the seed with incumbent cotyledons and an elongated superior or inferior radicle. In some cases the cotyledons are broad, thin, concave, and unequal, the larger one folding over the smaller.

An exceptional case occurs in Digera where the fruit is nutlike. A good type of the Order is represented by Amarantus hypochondriacus (fig. 607) which has a lenticular broadly elliptic or suborbicular seed with a peripheral circinate embryo. The cotyledons are linear, plano-convex, of the same length as the radicle, but slightly wider, and they lie across the narrow plane of the seed.

Seedlings.—The cotyledons vary between linear and lanceolate, and are often tinged or coloured red, pink, or violet, a peculiarity which is also characteristic of the leaves of many species in this Order. Those of Amarantus hypochondriacus (fig. 608) are linear-oblong, subcuspidate, one-nerved and petiolate as in other species.

The cotyledons of A. polygamus are slightly broader, lanceolate-oblong, and obtuse. The first two leaves are roundly ovate, emarginate at the base, and followed by four others which are larger and tend to be cordate at the base.

Scleropus amaranthoides has linear-oblong cotyledons and a hypocotyl varying from 1–2·7 cm. in length. The first four leaves are oblong, cuneate at the base, emarginate and much narrower than those of the above species; in the latter the venation is strongly incurved.

Amarantus hypochondriacus, *L.* (fig. 607).

Ovary one-celled, one-ovuled; ovule basal, vertical, campylotropous; micropyle inferior.

Fruit a pyxidium, small, ovoid, pale-coloured, glabrous, thin-walled, one-celled, one-seeded, dry, dehiscing transversely about the middle.

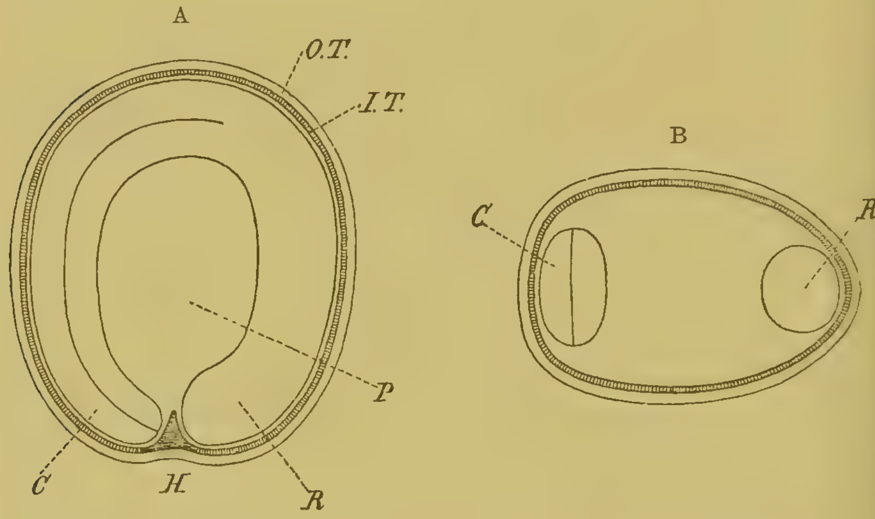

FIG. 607.—*Amarantus hypochondriacus*, × 28. A, vertical section of seed: *C*, cotyledon; *H*, hilum; *R*, radicle; *P*, endosperm; *OT*, testa; *IT*, tegmen. B, transverse section of seed: *R*, radicle; *C*, cotyledon.

Seed lenticular, broadly elliptic or more often orbicular in outline with a minute notch at the base, biconvex, deep brown or black and shining when mature, glabrous; testa crustaceous, brittle; tegmen very thin, membranous, white; hilum and micropyle contiguous, basal; raphe none.

Endosperm white, farinaceous, forming a very thin layer at the periphery of the seed, and surrounding the embryo, but forming a much larger mass within the curved embryo.

Embryo comparatively long, narrow and slender, much curved round and just within the extreme circumference or periphery of the endosperm, colourless; cotyledons incumbent, linear, obtuse, slender, plano-convex, lying in the narrow plane of the seed with their backs to the placenta, about equal to the radicle in length; radicle filiform or terete, curved round the periphery of the seed till it almost meets the tips of the cotyledons at the base of the seed and close to the hilum.

Seedling (fig. 608).

Radicle long, tapering downwards, slightly flexuose, with fibrous lateral rootlets, pink or flesh-coloured, annual.

Hypocotyl erect, terete, glabrous, deep red, 7–12 or 14 mm. long.

Cotyledons linear-oblong, obtuse, entire, subcuspidate, glabrous, one-nerved, petiolate, green and more or less suffused with red or pink, especially along the midrib; lamina tapering into the petiole, 6·5–10 mm. long, 2·5–3 mm. wide; petiole flat or slightly grooved above, convex beneath; 2–3·5 mm. long.

Stem herbaceous, annual, erect, terete, or more or less angled, or ridged and furrowed, slightly hairy, red; 1st internode 3·5–8·5 mm. long; 2nd 2·5–7 mm.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, slightly hairy and glandular on both surfaces when young, afterwards glabrescent, alternately penninerved with the nerves incurved towards their apex and uniting with one another by slender branches only; petioles semiterete, channelled above, and with the edges of the lamina decurrent and forming a very slender wing on the upper half, slightly hairy when young, especially on the upper edges, decurrent on the stem and forming ridges.

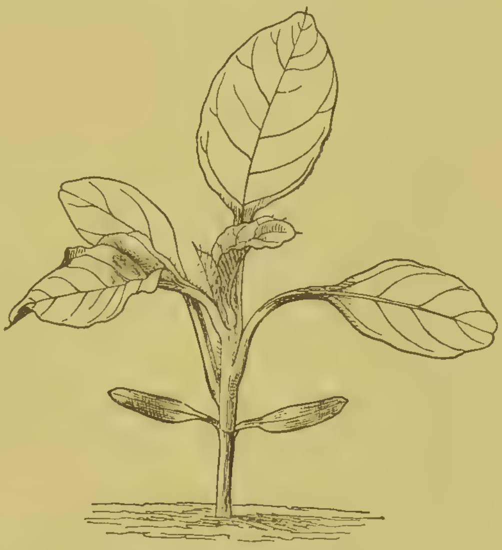

FIG. 608.—*Amarantus hypochondriacus*. Nat. size.

Nos. 1 and 2. Oval or elliptic, obtuse, entire or emarginate, green, or more or less stained with red.

Nos. 3–6. Oval, emarginate, with a bristle-like mucro in the notch, gradually larger, undulate at the margin when young, green or more or less stained with red.

Amarantus polygamus, *L.*

Primary root long, stout, fleshy, tough, pink, with numerous lateral rootlets.

Hypocotyl as in last species, deep violet red, 1·4 cm. long.

Cotyledons violet-red, greenish above, glabrous; lanceolate-oblong, obtuse, 1 cm. long, 4 mm. wide; petiole channelled above, 8·5 mm. long.

Stem herbaceous, annual, erect, angled, deep violet-red, pubescent; 1st and 2nd internodes 1 mm. long; 3rd 3 mm.; then numerous crowded internodes follow.

Leaves glabrous, thickened and slightly scabrous at the margin, subplicate, deep violet-red suffused with green above; petioles deeply channelled above, striate on the back, with raised or slightly winged margins alongside the channels, somewhat curved on the lower side at their insertion on the stem, slightly pubescent.

Nos. 1 and 2. Rotund-ovate, very obtuse, emarginate, subcuneate at the base.

Nos. 3–6. Rotund-ovate, very obtuse, emarginate, subcordate at the base.

Ultimate leaves ovate, retuse, apiculate, subdecurrent on the petiole at the base, glabrous, crisped at the margin, greenish-purple with crimson petiole, and nerves beneath.

Scleropus amaranthoides, *Schrad.*

Hypocotyl erect, terete, glabrous, 1–2·5 cm. long, stained with red.

Cotyledons linear-oblong, obtuse, entire, petiolate, membranous, glabrous, green, often tinged with red beneath, distinctly one-nerved.

Stem erect, terete, angled, herbaceous, glabrous; 1st internode 4–6 cm. long; 2nd and 3rd shorter.

First leaves simple, cauline, alternate, petiolate, exstipulate, oblong, entire or slightly emarginate, glabrous, pale green tinged with red beneath, distinctly alternately pinnatinerved.

CHENOPODIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 43.

Fruit and Seed.—The ovary is superior, quite free or immersed in the receptacle at the base only, but included in the perianth when that is present, ovoid, or globose and depressed, rarely oblong or flask-shaped, and one-celled. It is syncarpous and made up of two to three carpels. The ovule is solitary, basal and erect, or suspended from a long funicle, and amphitropous. The fruit is a utricle, membranous, coriaceous, or fleshy, generally included in the perianth and falling with it, indehiscent, rarely circumscissile, free or adhering to the testa. The seed is erect, inverted or horizontal, lenticular, subglobose, reniform or ovoid-compressed. The testa is crustaceous, leathery, fleshy or membranous, sometimes adhering to the endosperm, and consisting of a single or double layer. The endosperm is farinaceous, fleshy or wanting. The peripheral embryo is annular or horseshoe-shaped and surrounds the endosperm; it is rod-like and dorsal in the tribe Salicornieæ, or conduplicate and in the absence of endosperm occupies the whole seed. Endosperm is wanting in the tribe Salsoleæ and others when the embryo is flat or coiled like a shell. The cotyledons are, however, mostly narrow, plano-convex, or flat in a few, and slightly wider than the elongated radicle.

The seeds of Chenopodium Bonus-Henricus (fig. 609) are reniform, small and black with a crustaceous testa. The embryo entirely surrounds the periphery of the endosperm except a small portion at the hilum. The cotyledons are linear, plano-convex, lying in the narrow plane of the laterally compressed seed, incumbent, of the same length as the radicle, but slightly wider. The seed of Beta trigyna is globoso-reniform, grooved along one side, laterally compressed and often angular. It is suspended from near the apex of the utricle, and the superior radicle is shorter and thinner than the width of the cotyledons. The basal auricles of the seed are oblique or unequal.

The seeds of Atriplex hortensis are of two sizes, the small ones being black and similar to those of Chenopodium Bonus-Henricus, while the larger ones are brown and more orbicular. The large brown ones germinate much more quickly than the small black ones, which would seem, under natural conditions, to be more adapted to remain in a resting condition in the ground during the winter, and germinate in spring. If such is the case they would enable the plant to exist in a colder climate than the large ones would. Of a sowing made on October 29, one black seed germinated in four days, and three days later no more had come up, whereas thirty-two of the large brown seeds germinated in the seven days. On November 16, a sowing was made of thirty-five each of the black and brown seeds. In the course of six days, five of the brown seeds germinated, and only one black seed in the course of thirteen days, whereas by that time twenty-three of the brown seeds had germinated. Twenty-three days after being sown, ten of the black seeds had germinated, and twenty-six of the large brown ones. The seed of Chenopodium petiolare is small and orbicular and laterally compressed, but in other respects resembles that of C. Bonus-Henricus.

Seedlings.—The cotyledons coming under my notice are all of simple types, notwithstanding the difference in the seeds. Two of the types cannot be separated by hard and fast lines, as they gradually merge the one into the other. One of the simplest and widely prevailing forms is represented by Chenopodium Bonus-Henricus (fig. 610) which has linear-lanceolate cotyledons tapered gradually into petioles which are slightly connate at the base. The first two leaves are ovate, the third roundly cordate. The cotyledons of C. Quinoa are shorter and broader and, like the above, one-nerved. The first three leaves are oblong and mealy. The cotyledons of Blitum virgatum minus are small, linear and petiolate. A rather interesting evolution is shown by the leaves. The first is linear, the second spathulate, the third oblong, the fourth and fifth lanceolate-hastate, the sixth and seventh hastate, and the eighth to the twelfth inclusive cuneate, trifid, and trinerved. These characters vary, however, in different seedlings according to the vigour of the same. The cotyledons of Atriplex hortensis are similar to those of Blitum virgatum minus. The leaves are opposite, the two first pairs being oblong-ovate, followed by three other pairs which are triangular and variously toothed, angled, or hastate.

A relatively broader type is represented by Chenopodium ficifolium which has oblong-lanceolate, petiolate, one-nerved cotyledons. The two first leaves are opposite and oblong, followed by five which are alternate and lanceolate. The eighth to the thirteenth are more or less hastate, and in robust seedlings most of the primary ones show a tendency to be hastate. The cotyledons of Chenopodium viride are oblong, obtuse and mealy. The first pair of leaves are similar but broader. The cotyledons of Blitum virgatum (fig. 611) are lanceolate with long petioles. The first pair of leaves are lanceolate and subhastate.

Beta vulgaris has linear-oblong or spathulate cotyledons, and the first pair of leaves are broadly oval. Atriplex oblongifolia has elliptic-oblong, obtuse cotyledons, and the first pair of leaves are sagittate.

A number of seedlings are notable for the great length of their linear cotyledons. An instance of this is Spinacia oleracea. The first pair of leaves are broadly oval. The cotyledons of S. glabra (fig. 612) are much longer, more truly linear, and measure from 3 to 8 cm. in length. Those of Threlkeldia rostrata (fig. 613) are linear, fleshy, glandular-pubescent and recurved. The first thirty leaves at least are linear, fleshy and narrower than the cotyledons. The latter in Salsola Tragus are linear, semiterete, fleshy and 2·6–3·5 cm. long. The leaves are all terete and fleshy.

The most remarkable type I have noticed is that of Basella alba (fig. 614). The genus according to some authors constitutes the type of a distinct Order. The cotyledons are oblong, obtusely pointed, almost sessile, and fleshy with a few indistinct nerves on each side of the midrib, 5·9 cm. long and 2·2 cm. wide. The first two leaves are opposite or nearly so, broadly oval and obliquely emarginate.

Chenopodium petiolare, *H. B. K.*

Ovule campylotropous.

Seed small, from ·25–·5 mm. long, orbicular and somewhat laterally compressed; testa smooth; hilum inconspicuous.

Endosperm rather copious, central, surrounded by the peripherical embryo, greyish.

Embryo as in C. Bonus-Henricus.

Chenopodium Bonus-Henricus, *L.* (fig. 609).

Ovule vertical or rather horizontal, amphitropous; micropyle inferior.

Fruit a utricle, one-celled, one-seeded, indehiscent, small.

Seed reniform, subcompressed laterally, smooth, shining, black; testa crustaceous; hilum basal.

Endosperm floury, white, forming a mass on the basal side and centre of the seed, and a thin film round the periphery and between the embryo and the outer ridge of the seed.

Embryo curved and following the vertical ridge of the seed, and equal in length to this circumference; cotyledons linear, obtuse, plano-convex, lying in narrow plane of the seed; radicle cylindrical, obtuse, about equal in length to the cotyledons, with its tip close to the hilum as are the tips of the cotyledons.

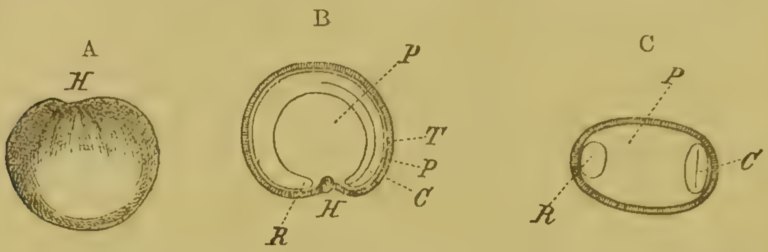

FIG. 609.—*Chenopodium Bonus-Henricus*, ×8. A, seed. B, vertical section of seed. C, transverse section of seed: *H*, hilum; *R*, radicle; *C*, cotyledon; *P*, *P*, endosperm.

Seedling (fig. 610).

Primary root tapering downwards, and giving off fibrous lateral rootlets.

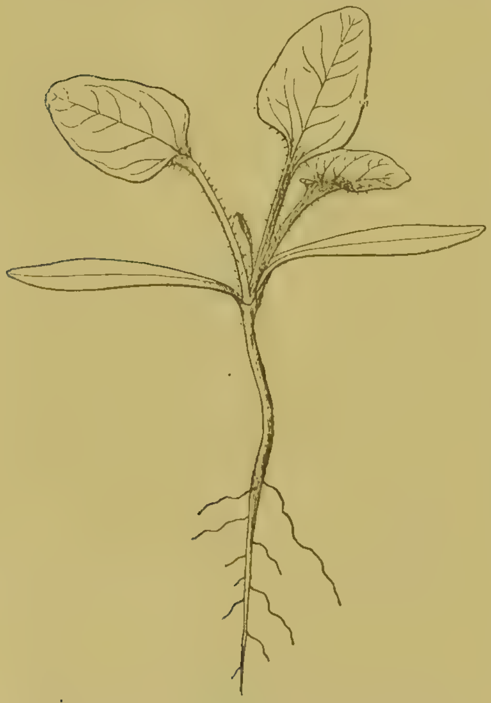

FIG. 610.—*Chenopodium Bonus-Henricus.* Nat. size.

Hypocotyl erect, terete, glabrous, red, 1–2 cm. long.

Cotyledons linear-lanceolate, obtuse, entire, tapered gradually into a long petiole, which is connate with its fellow at the base, forming a little cupule from which the plumule emerges, glabrous, green, traversed longitudinally by a distinct midrib, about 3 cm. long including the petiole; petiole flattened above or slightly grooved, convex on the back.

Stem herbaceous, developed when about to flower; primary internodes undeveloped.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, more or less farinose, especially on the under side, the petioles and the young leaves, alternately and ascendingly penninerved, obscurely reticulate ; petioles semiterete, rather deeply and narrowly channelled above, dilated and clasping at the base, tapering upwards.

Nos. 1 and 2. Ovate, obtuse, entire, cuneate at the base with lateral ascending nerves, incurved at their apices and uniting within the margin.

No. 3. Roundly cordate, obtuse or cuspidate, with rounded obtuse auricles at the base.

Chenopodium Quinoa, *Willd.*

Hypocotyl about 4 cm. long, light green or colourless, with a reddish tinge near the ground.

Cotyledons linear, obtuse, entire, 1–1·6 cm. long, tapering to the base but scarcely petiolate, thick, fleshy, glabrous, dark green, one-nerved.

Stem herbaceous, erect, terete, light green, glabrous or slightly mealy towards the leaves ; 1st internode 9–10 mm. long ; 2nd considerably shorter.

First leaves entire, cauline, opposite, decussate, shortly petiolate, oblong, obtuse, mealy, light green ; midrib with numerous lateral veinlets.

Chenopodium ficifolium, *Sm.*

Primary root as in C. Bonus-Henricus.

Hypocotyl becoming stouter upwards, glabrous, shining, brownish red, 1·5 cm. long.

Cotyledons caducous, oblong-lanceolate, obtuse, fleshy, petiolate, 6 mm. long including petiole.

Stem erect, terete, succulent, herbaceous, glabrous and shining towards the base, striped with red lines on a pale green ground, farinaceous upwards ; 1st internode 5·5 mm. long ; 2nd 6·5 mm. ; 3rd 3 mm. ; 4th 2·5 mm. ; 5th 3 mm. ; 6th 2 mm. ; 7th 2 mm.

Leaves cauline, alternate (first two opposite), petiolate, densely farinose when young, glabrescent above at an early period, and later on the under sides, bright green above when developed, paler beneath, subsucculent or fleshy ; petioles subterete, slightly channelled above, farinose, glabrescent.

Nos. 1 and 2. Opposite, oblong, obtuse, entire.

No. 3. Lanceolate-oblong, obtuse, slightly bidentate at the base.

No. 4. Lanceolate, obtuse, with one tooth near the base.

No. 5. Similar, but larger.

No. 6. Lanceolate, obtuse, subhastate, cuneate at the base.

No. 7. Similar, but larger.

No. 8. Oblong, obtuse, subhastate, cuneate at the base and distantly serrate above the basal lobes.

No. 9. Hastate, obtuse, cuneate and trinerved at the base.

Nos. 10–13. Similar, or slightly more serrate.

Chenopodium viride, *L.*

Hypocotyl thin, 2·5–3 cm. long, tinged with a deep red.

Cotyledons oblong, obtuse, fleshy, petiolate, entire, mealy, dark green tinged with red or purple beneath, indistinctly one-nerved.

Stem light green, mealy; primary internodes very short.

First leaves entire, cauline, opposite, decussate, oblong-oval, obtuse, with short petioles, mealy, light green above, tinged with red beneath, pinnatinerved.

Beta trigyna, *W. et Kit.*

Ovule pendulous from a basal funicle, campylotropous; micropyle superior, or pointing a little to one side.

Fruit a utricle, agglomerated in masses owing to the flowers being sessile, enclosed in and even adnate to the hardened and persistent perianth, surrounded by its five free persistent segments of the perianth and the cup-like base of the connate stamens, the filaments of which are free upwards, persistent, and folded over the apex of the utricle which is one-celled, one-seeded and indehiscent.

Seed subglobose, or somewhat angled or compressed, conforming to the interior of the utricle, notched at the base or subreniform and suspended from a basal funicle, glabrous, shining, black; tegmen rather thinner and paler coloured than the thin and subcrustaceous testa; hilum, micropyle, and chalaza contiguous, basal and superior; raphe none.

Endosperm forming a mass lying in the middle of the seed, between the radicle and cotyledons, and also a thin layer between the embryo and the testa, farinaceous and loose when dry, white.

Embryo peripheral, comparatively large, much curved, colourless; cotyledons oblong-linear, obtuse, entire, plano-convex, lying in the narrow way of the seed with their edges to the floral axis, longer than the radicle, and very little broader than its thickness, much curved, sometimes twisted; radicle thick, curved, tapered to an obtuse point, embedded in a very thin layer of endosperm and close to the micropyle.

Beta vulgaris, *Moq.*

Primary root tapering downwards, with a few fibrous lateral rootlets, red.

Hypocotyl scarcely appearing above ground.

Cotyledons subfleshy, unequal, linear-oblong, cuneate at the base, shortly petiolate, obtuse, entire, glabrous, green, one-nerved ; petioles red, furrowed on the upper face.

Stem with primary internodes undeveloped.

First leaves simple, entire, radical, alternate, broadly oblong or oval, petiolate, obtuse, glabrous, green, pinnatinerved ; petioles short, reddish, furrowed on the upper face.

Blitum virgatum, *L.* (fig. 611).

Primary root nearly vertical, small, brownish, with a few fibres.

Hypocotyl herbaceous, terete, glabrous, purplish-red, 1-2 cm. long, 1 mm. thick.

Cotyledons petiolate, nearly equal; blade about 1 cm. long, 3 or 4 mm. wide, obtuse, lanceolate, entire, obscurely nerved, thin but fleshy, glabrous, green above, pale beneath ; petiole as long as blade, 1 mm. wide.

Stem very short until about to flower.

Leaves simple, radical and cauline, alternate, exstipulate, petiolate, subfleshy, obscurely or distinctly alternately penninerved, more or less glandular-hairy (at least in the young stage).

Nos. 1 and 2. With shallow-channelled, glabrous, reddish petiole, 1·5 cm. long, 1–1·5 mm. wide, and an obtuse, lanceolate, obscurely basilobed blade, 1·5 cm. long and nearly 1 cm. wide, produced at the base, obscurely penninerved, glabrous, thin but fleshy, dull green above, purplish-red beneath, thinly glandular-hairy.

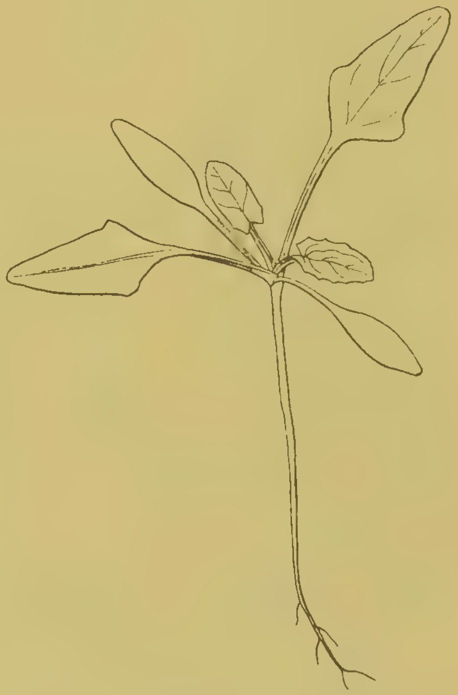

FIG. 611.—*Blitum virgatum.* Nat. size.

Nos. 3 and 4. Subhastate, sinuate-dentate, glandular-hairy on blade and petiole.

Atriplex hortensis, *L.*

This plant has two forms of seed.

1st. Subrotund, flattened laterally, 2·5–4 mm. in diameter (usually about 3 mm.), flat or concave on the sides; testa thin, membranous, light brown or straw-coloured, smooth, not shining.

2nd. Subrotund, slightly flattened laterally, 1·5–2·5 mm. in diameter, biconvex; testa rather thick, crustaceous, bright black, smooth and shining.

Both kinds of seed are usually enclosed in the membranous, thin, indehiscent utricle.

In some sowings which I made, the brown seeds came up more quickly than the black, as if the black were intended to remain for a while dormant. The subject, however, requires further study.

Seedling.

Primary root tapering downwards, flexuose, yellowish, with short lateral rootlets, annual.

Hypocotyl erect, terete, glabrous, short and merging indistinguishably into the root.

Cotyledons petiolate, falling away early, linear, obtuse, about 1 cm. long including the petiole.

Stem erect, terete, herbaceous, annual, pale green, glabrous, shining, farinaceous in the upper and younger part; 1st internode 1·5 mm. long; 2nd 3 mm.; 3rd 9 mm; 4th 10·5 mm.

Leaves simple, cauline, opposite, or the upper ones alternate, petiolate, mealy when young, smooth and glabrous when mature, pale green, or in the garden variety rubra of a deep reddish-purple especially in the young state, trinerved at the base with a branch from the lateral nerves into the basal lobes; petioles subterete, slightly flattened on the upper side and narrowly channelled, glabrous.

First pair oblong-ovate, obtuse, truncate, and sometimes with a minute lateral tooth on each side at the base, very faintly trinerved.

Second pair similar, but larger.

Third pair in robust specimens triangular, obtuse, minutely and obsoletely dentate or entire, truncate at the base.

Fourth pair triangular, subacute, minutely denticulate, hastate, truncate at the base.

Fifth pair triangular, subacute, sagittate-hastate, more deeply dentate on the lower half.

Ultimate leaves large, triangular, sagittate-hastate, subcuspidate, irregularly repand, serrate-dentate except towards the point, trinerved with a strong branch from the lateral nerves entering the basal lobes.

Uppermost leaves near the inflorescence again becoming smaller and less decidedly cut.

Atriplex oblongifolia, *W. et Kit.*

Hypocotyl 3–6·5 cm. long,

Cotyledons elliptic-oblong, entire, obtuse, shortly petiolate, glabrous, dark green, one-nerved.

Stem erect, terete, herbaceous, mealy; first internode 2–3 mm. long.

First leaves opposite, decussate, sagittate, pinnatifid.

Spinacia glabra, *Mill.* (fig. 612).

Hypocotyl erect, terete, glabrous, 1·5–2·5 mm. long, colourless or tinged with red.

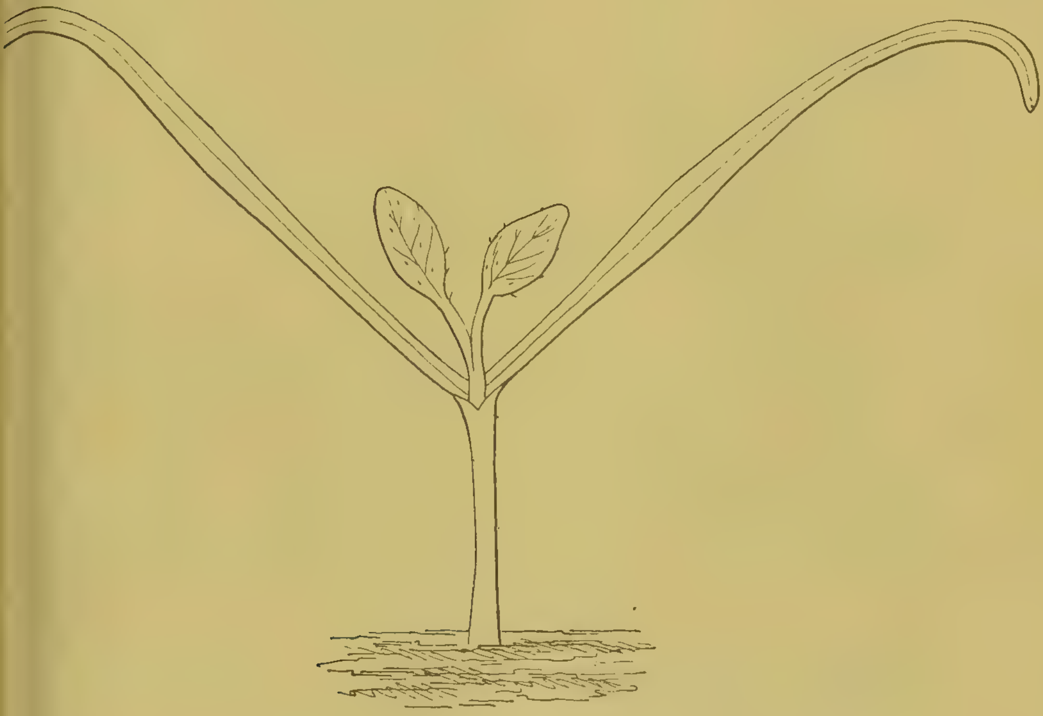

FIG. 612.—*Spinacia glabra.* Nat. size.

Cotyledons linear, acute, fleshy, 3–8 cm. long, entire, glabrous, bright green, one-nerved, tapering to the base.

Stem erect, herbaceous; primary internodes very slightly developed.

First leaves oval or ovate, obtuse, entire, simple, cauline, opposite, petiolate, very slightly mealy above, glabrous beneath, green, pinnatinerved.

Spinacia oleracea, *Mill.*

Hypocotyl thickened upwards, 6–8 mm. long.

Cotyledons subfleshy, unequal, linear, subacute, entire, sessile, tapering to the base, glabrous, light green, distinctly one-nerved.

Stem with primary internodes undeveloped.

First leaves radical, opposite, afterwards alternate, broadly ovate-oblong or oval, obtuse, shortly petiolate, glabrous, light green, pinnatinerved; petioles flattened, channelled on the upper side, glabrous.

Threlkeldia rostrata, *? F. Muell.* (fig. 613).

Hypocotyl erect, terete, pale green, minutely glandular-pubescent, about 1·6 cm. above the soil.

Cotyledons linear, obtuse, fleshy, pale green, sessile, minutely glandular-pubescent, or slightly hairy on the midrib beneath, narrowed to the base and subconnate, 3 cm. long, 3·5 mm. wide.

Stem primarily erect, terete, pale green, minutely glandular-pubescent, ultimately subshrubby; 1st internode 4·5 mm. long; 2nd ·5 mm.; 3rd 4 mm.; others similar.

Leaves simple, entire, cauline, alternate, sessile, minutely and thinly glandular-pubescent, except in the young state when the glandular hairs are more numerous, fleshy, pale green, slightly channelled, linear, obtuse, all similar in the seedling, narrower than the cotyledons.

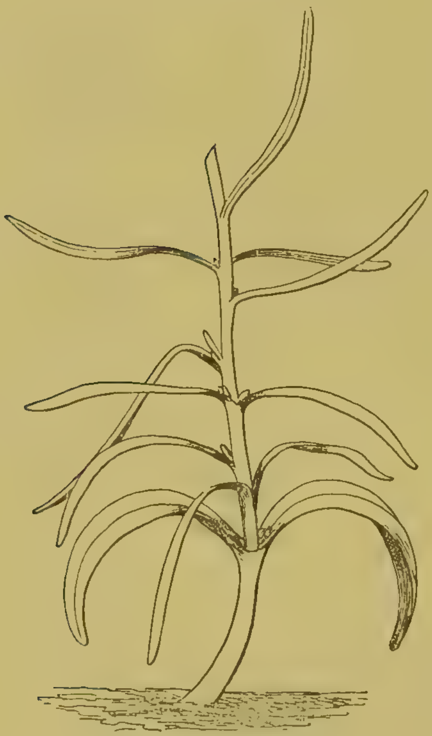

FIG. 613.—*Threlkeldia rostrata.* Nat. size.

Nos. 1–30. Linear, obtuse, fleshy, narrow.

Salsola Tragus, *L.*

Hypocotyl slender, or wiry, erect, terete, glabrous, red, 2–4·5 cm. above the soil.

Cotyledons linear, obtuse, sessile, fleshy, semiterete, flattened above, sheathing the plumule, that is connate at the base, frequently both directed to one side, glabrous, 2·6–3·5 cm. long.

Stem herbaceous, erect, terete, finely ridged and furrowed, striated with red and green, scabrous or coarsely pubescent especially on the ridges.

Leaves simple, entire, cauline, terete, tipped with a bristle, fleshy, channelled on the upper side at the base only, which resembles a clasping petiole, and slightly pubescent, otherwise the leaf is glabrous.

First, second, and sometimes more of the lower pairs opposite, while the upper ones are alternate.

Basella alba, *L.* (fig. 614).

Hypocotyl erect, terete, succulent, glabrous, pale green, purplish at the base, 2–3 cm. above the soil, 5 mm. thick.

Stem erect, succulent, glabrous, pale green; 1st internode 1 cm. long.

Cotyledons large, oblong, obtusely pointed, foliaceous, glabrous, succulent, pale green, obscurely and alternately penninerved, shortly petiolate, 5·9 cm. long including the petiole, 2·2 cm. wide.

Leaves simple, cauline, alternate, petiolate, succulent, glabrous, subreticulate, or rather obscurely reticulate, tapering into the short fleshy petiole which is slightly channelled above, and articulated with the stem.

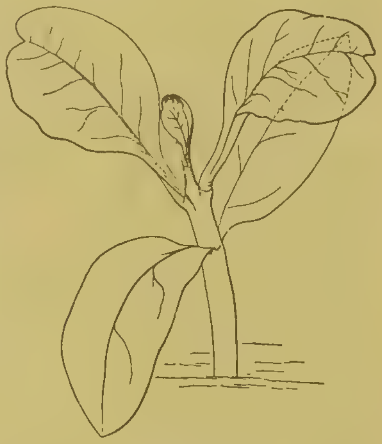

Fig. 614.—*Basella alba.* Half nat. size.

Nos. 1 and 2. Opposite, oval, retuse, somewhat obliquely emarginate.

No. 3. Alternate, otherwise like the first two.

PHYTOLACCACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 78.

Fruit and Seed.—The ovary is superior and consists of one or several distinct or connate carpels, inserted on a flat or very rarely elevated receptacle. The ovules are solitary in each carpel, attached by a short funicle to the base of the cavity, more rarely to the inner angle of the cell, and amphitropous or campylotropous. There is frequently a spongy arillode at the micropyle. The fruit is monocarpellary and crustaceous, coriaceous, baccate or samaroid, or it is polycarpellary, with one-celled, one-seeded, free or connate carpels. The seed is erect, very rarely ascending, and globose, reniform or lenticular and compressed. The testa is membranous or crustaceous, and smooth, rugose or downy. A small bilobed aril is frequently present; but in Stegnosperma it is large and covers the seed. The embryo is relatively large, peripherical, and surrounds the farinaceous or fleshy endosperm. In elongated seeds it is hooked or abruptly deflexed at the apex. The cotyledons are incumbent, foliaceous, and plicate-convolute, or linear, narrow and semiterete or plano-convex. The radicle is elongated and close to the hilum.

Some exceptional cases occur in the Order. The ovary is half inferior in Agdestis; and in Stegnosperma it is one-celled and many-ovuled, while the fruit is three-valved and three- to five-seeded. The large aril of Stegnosperma is also notable.

At least three distinct types of seeds have come under my observation. The simplest, represented by Phytolacca pruinosa, is exactly similar to what occurs in Illecebraceæ and Chenopodiaceæ. The seed is reniform, laterally compressed with a large peripheral embryo surrounding a moderate quantity of farinaceous endosperm. The cotyledons are linear, plano-convex, slightly wider than the radicle and about twice as long. The seed of P. acinosa corresponds closely to that of its congener.

The seed of Rivina lævis is small, orbicular, laterally compressed, notched at the base, densely pubescent and unequal in thickness. The embryo is curved, horse-shoe fashion, round the endosperm; but the cotyledons are very wide, thin, longitudinally convolute and somewhat longer than the radicle. The position is best seen in transverse section. A vertical section shows four pieces as if there were four cotyledons.

The fruit of Petiveria octandra (fig. 616) is an achene surmounted by two to six sharply reflexed hooks of unequal size. The embryo is sharply doubled upon itself and nearly peripherical on two sides of the seed with the greater bulk of the endosperm occupying the other two sides. The cotyledons are convolute longitudinally, but very unequal. The broader one is outermost, deeply auricled at the base and trilobulate at the apex. The smaller one is much the longest, auricled at the base but otherwise entire, and convolute inside the larger one in its lower half only.

Seedlings.—The cotyledons seem always to be broad. Those of Phytolacca abyssinica (fig. 618) are lanceolate-ovate, slightly unequal, cuneate at the base, rather fleshy, indistinctly penninerved, 3–5 cm. long, and 1·5–2 cm. wide. The first two leaves are ovate-elliptic.

The cotyledons of Rivina lævis (fig. 615) are rotund, subcordate, trinerved, obtusely cuspidate, and reticulate. The primary leaves are cordate. A slight difference occurs in the cotyledons of R. canescens which are reniform, slightly unequal, rounded at the apex, trinerved and entire. The first two leaves are ovate.

The cotyledons of Petiveria octandra (fig. 617) are very unequal. The shorter one is much the broader, triangular or subcordate, obscurely trilobate at the apex, and otherwise somewhat indented at the sides, but this latter characteristic may not be constant; it is penninerved, with the basal pair of laterals strongly developed. It is about 2 cm. long and 1·75 cm. wide. The longer cotyledon is oblong, obtuse, penninerved, 3 cm. long, and 1·25 cm. wide.

Rivina lævis, *L.*

Ovary of one carpel, one-celled, one-ovuled; ovule basal, erect, amphitropous; micropyle inferior or pointing to the base of the seed close to the hilum.

Fruit baccate, subglobose, laterally compressed, tipped by the persistent style, glabrous, scarlet, one-seeded.

Seed vertical, laterally compressed, deep brown or black, densely pubescent; hilum small, basal, slightly depressed, with the depression almost filled with a small, colourless, bilobed, funicular aril.

Endosperm copious, white, farinaceous, lying inside the embryo, or between that and the hilum.

Embryo curved round the whole periphery of the seed except a small part close to the hilum, fleshy, soft, colourless; cotyledons longitudinally convolute, forming a thick cylinder, and when vertically cut giving the appearance of four cotyledons ; radicle cylindrical, bluntly pointed, somewhat longer than the cotyledons, with its apex near the hilum.

Seedling (fig. 615).

Primary root nearly vertical, light red, with numerous slender, branched, lateral rootlets.

Hypocotyl herbaceous, about 2 cm. long, 1 mm. thick, terete, glabrous, brown.

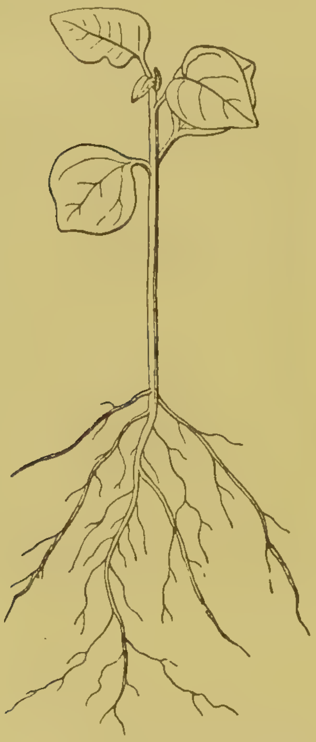

FIG. 615.—*Rivina lævis.* Nat. size.

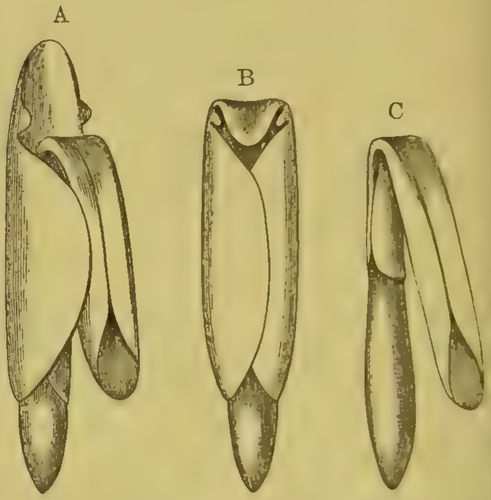

FIG. 616.—*Petiveria octandra.* Embryo and cotyledons, × 6. A, embryo partly unfolded. B, outer and shorter cotyledon. C, inner and longer cotyledon.

Cotyledons not quite opposite, petiolate, unequal, about 1·5 cm. long, a little over 1 cm. wide, broadly cordate or suborbicular, shortly and obtusely cuspidate, trinerved, thin, glabrous, bright green, not very persistent ; petioles slightly channelled, red, glandular.

Stem like the hypocotyl ; bases of leaves decurrent.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, alternately incurvinerved, glabrous, subreticulate, membranous, deep green above, paler beneath.

Nos. 1 and 2. Cordate, acute, incurvinerved.

Petiveria octandra, *L.* (fig. 616).

Ovary of two carpels, one-celled, one-ovuled; ovule basal, erect, amphitropous; micropyle inferior.

Fruit an achene, oblong-linear, subcuneate, laterally compressed and surrounded longitudinally with a median ridge on both sides, longitudinally striated and sulcate, bifid at the apex and crowned with two to six unequal-sized, closely reflexed acute bristles, more or less hairy, brown; pericarp coriaceous, closely adhering to the seed.

Seed oblong-linear, conforming to the interior of the achene; testa membranous; tegmen adhering to the endosperm; hilum basal, somewhat oblique; micropyle contiguous to the hilum; raphe none.

Endosperm moderately copious, whitish, subfarinaceous or fleshy.

Embryo large, surrounded by the endosperm, doubled upon itself; cotyledons very unequal, and often only one, the smaller being aborted; larger one very broad, deeply cordate at the base, strongly convolute and enclosing the smaller when present; apex subtrilobate, with rounded obtuse lobes, the lateral ones curving round the smaller cotyledon, while the middle one is curved at the apex and just within the endosperm at the apex of the seed; inner one much longer, convolute within the larger one, refracted near the middle, just within the apex of the endosperm and carried down again nearly to the tip of the radicle; radicle stout, cylindrical, obtuse, rather long, close to the micropyle at the base of the seed.

Seedling (fig. 617).

Primary root slender, with many colourless branched fibrous rootlets.

Hypocotyl herbaceous, about 2 cm. long, 1 mm. thick, slightly ridged, pubescent, green or brownish-red.

Cotyledons very unequal, stalked, generally one is about 2 cm. long, 1·75 cm. wide, subcordate, obtusely cuspidate, coarsely crenate, sinuate near the apex, trinerved at the base, penninerved. The other is about 3 cm. long, 1·25 cm. wide, oblong, obtuse at both ends, entire, penninerved; both are glabrous except the short pubescent petioles, thin, with sunk midrib, bright green, not very persistent.

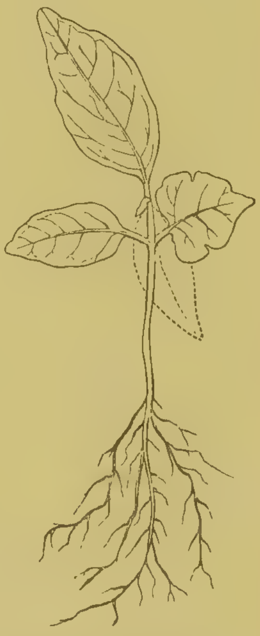

Fig. 617.
Petiveria octandra.
Half nat. size.

Stem herbaceous, erect; 1st internode 6 mm. long, 1–1·5 mm. thick, terete, pubescent, brown.

Leaves simple, entire, cauline, alternate, stipulate, petiolate, alternately incurvinerved, glabrous or somewhat pubescent, membranous, smelling strongly of garlic ; stipules small.

Nos. 1–3. Very much like the entire cotyledon, only larger, 4–5 cm. long, nearly 2 cm. wide ; apex oblique ; margin sinuate.

Phytolacca pruinosa, *Fenzl.*

Pistil apocarpous or very nearly so, of six to eight carpels, each one-celled, one-ovuled ; ovules erect, campylotropous ; micropyle inferior.

Fruit baccate, of six to eight juicy carpels arranged in a whorl, slightly united by their bases laterally but not in the centre, glabrous, deep black, shining.

Seed reniform, vertical, somewhat compressed laterally, with a hard, crustaceous, deep black and shining testa, glabrous, unequal at the base—the smaller auricle containing the radicle, the larger the cotyledons ; hilum basal in the notch ; micropyle close to it.

Endosperm central, floury, loose, white.

Embryo much curved, peripheral, not so white as the endosperm which it encloses, comparatively large ; cotyledons linear, obtuse, semiterete, plano-convex, placed with their backs to the axis, and their edges to the compressed sides of the seed ; radicle cylindrical, obtusely pointed, about half as long as the cotyledons.

Phytolacca acinosa, *Roxb.*

Fruit of six to eight one-seeded, baccate, drupe-like carpels.

Seed oblong, 3–4 mm. long, laterally compressed ; testa smooth, shining, black, crustaceous ; hilum rather conspicuous.

Endosperm rather copious, white, farinaceous, surrounded by the embryo.

Embryo curved, lying round the endosperm, colourless ; cotyledons linear, obtuse, entire, closely adpressed, lying the narrow way of the seed, with their faces to the axis ; radicle terete, obtuse, incumbent, shorter than the cotyledons.

Phytolacca abyssinica, *Hoffm.* (fig. 618).

Hypocotyl 1–2 cm. long, 2 or 3 mm. thick, terete, glabrous, reddish, succulent.

Cotyledons shortly stalked, nearly equal, 3–5 cm. long, 1·5–2 cm. wide, lanceolate-ovate, acute and produced at the base, subacute at the apex, entire, with sunk midrib, obscurely penninerved, glabrous, fleshy but not thick, yellowish-green ; petiole 1 cm. long, 2–3 mm. wide, stout, channelled.

Stem terete, succulent, edges of petiole decurrent, glabrous, purplish-brown; internodes about 1 cm. long, as thick as the hypocotyl.

Leaves simple, entire, cauline, alternate (first two opposite), exstipulate, petiolate, alternately incurvinerved, glabrous, subfleshy; petiole grooved on the upper side.

Nos. 1 and 2. 5–7 cm. long, 2·5–3 cm. wide, with stout, channelled, reddish petioles 1 cm. long, 2·5 mm. wide, and an ovate-elliptic, acute, entire, mucronate blade.

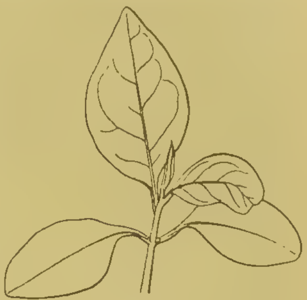

FIG. 618.
Phytolacca abyssinica.
Half nat. size.

POLYGONACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 88.

Fruit and Seed.—The ovary is superior, rarely slightly sunk in the receptacle, syncarpous, and consists of two to three, rarely four carpels, trigonous, or compressed, rarely tetragonal, one-celled, with a basal, erect, orthotropous ovule; the ovule is sessile or erect on the apex of a funicle, sometimes pendulous from the recurved apex of an elongated basal funicle. The fruit is nutlike, trigonous, compressed or rarely tetragonal, and indehiscent, clothed by the unchanged or accrescent perianth, rarely exserted from it. The pericarp is crustaceous, rarely leathery or hardened. The seed is sessile, erect and orthotropous, rarely stipitate, and conforms to the interior of the fruit; sometimes it is longitudinally furrowed and three- to six-lobed. The testa is membranous and filled with copious farinaceous endosperm, rarely is the endosperm subfleshy and scanty. The embryo is often more or less excentric or lateral, variously curved or straight, sometimes peripherical. The cotyledons are flat, narrow or wide, rarely very wide and convolute. The radicle varies considerably in length and is superior or ascending.

The pistil is tetramerous in Calligonum. The ovule is suspended from a recurved funicle in Leptogonum, Brunnichia, and Antigonon. The perianth completely encloses the fruit, or is solid in Oxygonum, Emex, and Symmeria, fleshy or baccate in Muehlenbeckia, Coccoloba, and in a few species of Polygonum. It is adnate to the nut in several species of Coccoloba.

Reckoned according to the form and position of the embryo, three different types of seeds have come under my observation. In all cases the seed itself is trigonous, and conforms to the interior of the fruit. The simplest form is represented by Rumex obtusifolius. The embryo is straight or slightly curved in conformity with the outline of the seed, as it is excentric and lies along one of the three faces outside the endosperm. The cotyledons are oblong, plano-convex, and somewhat longer than the terete radicle. The fruit and seed of R. Patientia are more decidedly narrowed to the base and ellipsoid; the embryo is excentric, as long as the seed, and therefore much curved in conformity with it. The cotyledons are linear, plano-convex, narrow, and longer than the terete radicle.

The embryo of Rheum palmatum (fig. 621) is relatively larger and generally slightly excentric, with broadly oblong cotyledons, abruptly narrowed into the radicle which is short, terete, and lies in the narrow neck of the seed quite uncovered by endosperm. The cotyledons are flat or more or less folded longitudinally, and exceptional cases occur where one is oblique to the other, and in one instance they were twisted at right angles to one another so as to occupy the three angles of the seed and thus attain the greatest possible size. The fruit is broadly three-winged, and the inner wall is greatly but unequally thickened, suberous, and so indents the testa and endosperm in places as to make the latter appear ruminated.

The seed of R. officinale is not abruptly narrowed at the apex so that the radicle remains embedded in endosperm. The embryo as a whole is nearly if not quite central, with narrowly oblong cotyledons slightly longer than the radicle, and is relatively smaller than that of R. palmatum.

The seed of Fagopyrum esculentum (fig. 619) is large, ovoid-trigonous, rarely with the angles nearly obliterated and rounded. The embryo is relatively very large, variously folded and convolute longitudinally, similar to what occurs in Geranium, except that endosperm is here present and is nearly divided in half by the cotyledons. In transverse section the latter are seen to be twisted in the form of the letter S, with endosperm occupying the sinus. They are deeply but unequally auricled at the base, and the two halves of the lamina are unequal, and the whole therefore unsymmetrical for the same reason as in Geranium. The larger halves are outermost and hug the testa, closely following two out of the three angles of the seed and enclosing the smaller halves. The latter retain their smaller size after germination. The radicle is large, fusiform, and completely enclosed by the folds of the cotyledons.

The cause of the inequality in the two halves and of the auricles of the cotyledons is as follows:—

The embryo in the young state becoming too wide for the interior of the seed, becomes first folded together longitudinally, and growth continuing the cotyledons become spirally convolute, forming a large open spiral with all the intermediate spaces filled with the white floury endosperm. The cotyledons at length get outside the endosperm and direct their course into two out of the three angles of the seed, thus obtaining the greatest possible width. Looking from the apex of the seed—that is, from the radicular end of the embryo to the lower end of the seed—the cotyledons are after the first folding both twisted in the same direction, from right to left, or in the opposite direction to the course of the sun, or this direction may be reversed. In consequence of this one half of each cotyledon is enclosed by the corresponding half of the other, so that the outer half of each has more room to develop, and is both larger and has larger auricles.

Seedlings.—The cotyledons vary greatly in size and shape, sometimes even in the same genus. Those of Pterostegia drymarioides are rotund, obtuse, entire, and petiolate with a lamina 6·5–7·5 mm. long and the same in width. In the case of Polygonum sphærostachyum they are rotund, trinerved, and taper slightly at the base into short petioles, connate at the base, forming a cup round the axis. The cotyledons of Rumex Bucephalophorus are narrowly ovate-oblong; and the two primary leaves are oval. The cotyledons of a species of Himalayan Rheum from the Saharanpur gardens (N.W. India) are large, foliaceous, ovate-oblong, and obtuse. The cotyledons of Rheum officinale (fig. 622) are broadly ovate, obtuse, obscurely three- to five-nerved, and have their petioles slightly connate at the base. The hypocotyl is undeveloped or indistinguishable from the root, which becomes thick and fleshy at an early stage. The first leaf is ovate-oblong, subcordate at the base. The ultimate leaf is cordate-palmate, five-nerved and -lobed, and lobulate or coarsely dentate between the lobes.

A very distinct type is met with in Coccoloba uvifera (fig. 623) which has cotyledons similar to those of Coffea. They are large, foliaceous, oblate or subquadrate, five-nerved from the base, strongly reticulate, and truncate at the apex or widely, shallowly and erosely emarginate.

The large and foliaceous cotyledons of Fagopyrum are also very distinct. They are more or less unsymmetrical with unequal basal auricles as explained above. Those of F. emarginatum are rhomboid-orbicular, unsymmetrical, five-nerved at the base and penninerved upwards. The first leaf is cordate-hastate, and the second similar but more acuminate, with ochreate stipules as in other members of the Order. The cotyledons of F. tataricum (fig. 620) are suborbicular, rounded at the apex, and very unequally auricled at the base with the larger auricle of one on the opposite side from that of the other as it was developed in the seed. The venation is similar to that of the last species.

Pterostegia drymarioides, *Fisch. et Mey.*

Primary root slender, flexuose, finely branched.

Hypocotyl short, subterranean and scarcely distinguishable from the root, red.

Cotyledons rotund, obtuse, entire, petiolate, glabrous; lamina 6·5–7·5 mm. long, and about the same in width; petiole slender, slightly furrowed on the upper surface, 9–11 mm. long.

Stem herbaceous, dichotomously branched; 1st internode undeveloped; 2nd 5–9 mm. long.

Leaves simple, radical and cauline, opposite, unequal, stipulate, petiolate, very thinly pubescent or almost glabrous; petiole slender, slightly channelled above. Inequality of leaves; lamina 6·5–7·5 mm. long and 1–1·3 cm. wide; petioles 1·7–2 cm.

Stipules represented by a slender connecting rim between the petioles or by their slightly connate bases.

First to third pairs oblate, emarginate or bifid, like the cotyledon of a Convolvulus or Brassica, giving off a few leading nerves into the side lobes.

Polygonum sphærostachyum, *Meisn.*

Primary root normal.

Hypocotyl very short and unapparent.

Cotyledons entire, almost orbicular, about 4 mm. in diameter, glabrous, trinerved, with long petioles from 1·5–2 cm., which joining at the base of the leaf form a hollow tube through which the real leaves pass, giving the appearance of an erect hypocotyl with sessile cotyledons.

Stem at first very short, so that the leaves appear radical.

First leaves radical, obtusely lanceolate, alternate, simple, entire, light green with long petioles from 2·5–3 cm.; midrib with numerous lateral veinlets.

Fagopyrum esculentum, *Moench.* (fig. 619).

Fruit an achene, acutely or obtusely trigonous or sub-three-winged, crustaceous, brown, sometimes with black transverse stripes, or entirely black, glabrous, much longer than the persistent withered perianth, slightly narrowed to the base, but more to the apex.

Seed large, ovoid-trigonous, filling the cavity of the ovary and conforming to it in shape; testa very pale brown or straw-coloured, glabrous, shining; hilum basal; chalaza rather large, conspicuous, orbicular, reddish-brown, basal; micropyle apical.

Endosperm copious, dry and floury, white.

Embryo very large, lying in the centre of the endosperm and variously stretched from one angle of the seed to another, and equal in length to the seed, straight; cotyledons very wide, variously twisted about or plaited, often striking into two out of the three angles of the seed, and these following the interior of the testa for some distance, apparently outside the endosperm, very shortly petiolate; radicle rather large, subfusiform, tapering to an obtuse point, completely hidden by the folds of the cotyledons.

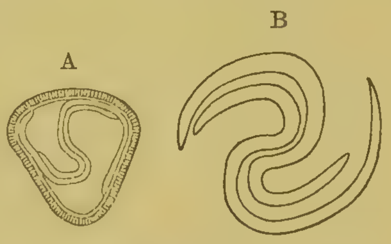

FIG. 619.—*Fagopyrum esculentum.* A, transverse section of seed, × 4. B, embryo, × 8.

Seedling.

Hypocotyl 6–12 cm. long, 1·5–2·5 mm. thick, succulent, terete, glabrous, red.

Cotyledons nearly equal, obtuse, rhomboid-orbicular, oblique, entire, penninerved, plane, glabrous, thin but fleshy, pale green, 1–2 cm. long, and 2–3·5 cm. wide; petioles channelled, glabrous, succulent, reddish, connate at the base, 1·5–2 cm. long, about 1 mm. thick.

Stem succulent, terete, glabrous, reddish; 1st internode 3–7 cm. long, 1·25–2 mm. thick; 2nd shorter and thinner.

Leaves rather membranous, three- to five-nerved at the base, and penninerved upwards.

No. 1. 3–5 cm. long, 2–4·5 cm. wide, cordate-hastate, obtusely acuminate, entire, palmatinerved, thin, with mealy pubescence, light green; petiole channelled above, glabrous or slightly pubescent.

No. 2. Similar but more acuminate.

Fagopyrum tataricum, *Gaertn.* (fig. 620).

Primary root long, tapering downwards, colourless, giving off short, slender, lateral fibres.

Hypocotyl erect, terete, minutely glandular-pubescent, red, striated with darker lines, shining, 2–2·8 cm. above the soil and tapering insensibly into the root.

Cotyledons suborbicular, rounded at the apex, cordate at the base and unequally auricled, the longer auricle of one cotyledon on the opposite side to that of the other, while the lamina is generally larger on the side with the longer auricle, faintly five-nerved at the base, petiolate, deep subglaucous-green above, paler beneath, glaucous and slightly reticulate; lamina 1·3–1·5 cm. long, including the auricles, 1·2–1·4 cm. wide; short side of a typical, good-sized cotyledon 1·1 cm. long, 5·75 mm. wide; longer side 1·4 cm. long, 8·5 mm. wide; petioles semiterete, channelled above, glabrous, shining, dilated and connate at the base forming a cup round the plumule, tapering upwards and becoming rather slender, unequal in length; longer one in specimen described 2·7 cm. long; shorter one 2·15 cm.

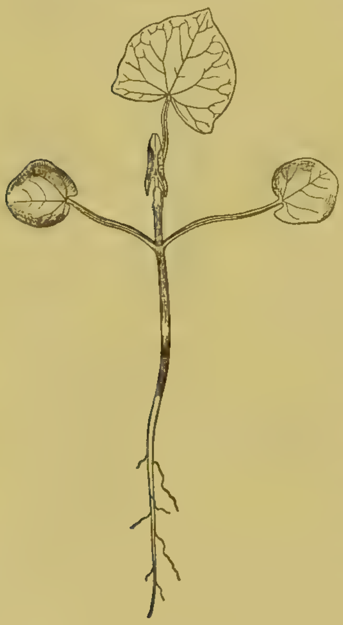

FIG. 620.
Fagopyrum tataricum.
Half nat. size.

Stem erect, terete or somewhat flattened on two sides, thinly pubescent on the internodes and more densely so at the nodes or papillose, pale green closely striated with red lines; 1st internode 6–9 mm. long.

Leaves simple, cauline, alternate, stipulate, petiolate, five-nerved at the base and alternately nerved upwards, with branching anastomosing veins, deep glaucous-green above, paler and glaucous beneath, glabrous; petioles semiterete, channelled on the upper side, tapering upwards from a stout base, pale green, pubescent or papillose at the margins on the upper side, shining; stipules connate by their edges and forming a sheath around the stem to which their bases are adnate, thin and membranous for the greater part, entire or lacerated at their free upper edges, glandular-pubescent or papillose, pale green or almost colourless.

No. 1. Reniform-triangular, subhastate, cuspidate, acute, five-nerved at the base, alternately nerved upwards, and reticulate.

Rheum palmatum, *L.* (fig. 621).

Ovary one-celled, one-ovuled; ovule basal, erect, orthotropous; micropyle superior.

Fruit an achene, surrounded at the very base with the persistent remains of the perianth, ovoid-trigonous, broadly and thinly three-winged, suddenly tapering to a cuneate base, tipped with the base of the styles, dark brown, glabrous; wings traversed longitudinally with a nerve running nearer the margin than the attachment, reticulate, pale brown.

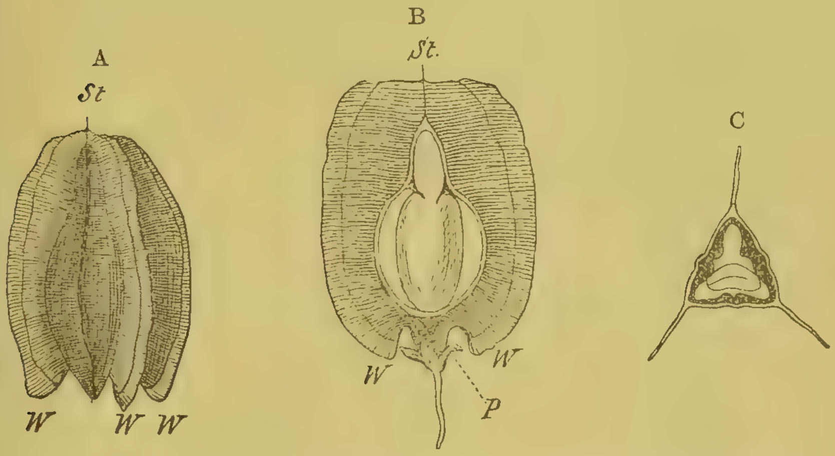

Fig. 621.—*Rheum palmatum.*—A, achene, × 3: *St*, style; *W*, *W*, *W*, wings. B, longitudinal section of achene, × 3: *St*, style; *W*, *W*, wings; *P*, perianth. C, transverse section of achene, × 3.

Seed trigonous, conical or flask-shaped, suddenly narrowed at the base, gradually narrowed to the apex, conforming in shape to the fruit except the wings, raised into a more or less prominent ridge on each of its three faces; testa thin, red, more or less adhering to the suberous endocarp; hilum and chalaza basal and inconspicuous.

Endosperm copious, floury, white when dry but yellow when moist, surrounding the embryo except the radicle and sometimes the edges of the cotyledons, appearing somewhat ruminated in transverse section owing to the unequal thickening of the corky endocarp.

Embryo straight, large, generally slightly excentric, colourless; cotyledons oblong, obtuse, entire, abruptly narrowed into the radicle, lying near one side of the triangle in the transverse section of the seed, and flat or slightly bent or doubled upon themselves longitudinally; radicle short, stout, narrowed to an obtuse point and lying in the apex of the seed uncovered by the endosperm.

Exceptions to the position of the cotyledons occur where one is oblique to the other, often lying against the sides of the seed from the absorption of the endosperm at their edges. A case occurred where one cotyledon was twisted at right angles to the other, so as to occupy the three angles of the seed.

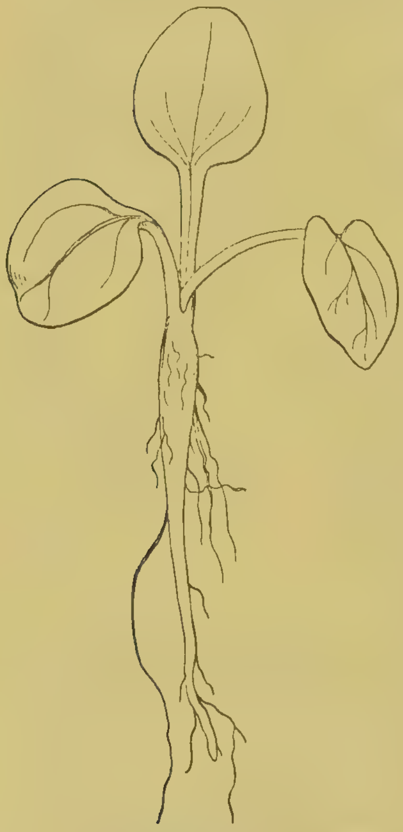

Fig. 622.—*Rheum officinale.* Nat. size.

Rheum officinale, *Baill.* (fig. 622).

Primary root stout, fleshy, tapering downwards, with lateral fibres, brownish.

Hypocotyl very short, fleshy, brownish, hardly distinguishable from the root, about 6 mm. long.

Cotyledons broadly ovate, obtuse, three- or obscurely five-nerved, entire, scabrous at the margin, glabrous, fleshy, light opaque green; lamina 1·65 cm. long, 1·4 cm. wide; petioles flattened above, convex on the back, pale green or suffused with red, glabrous, connate at the base forming a sheath for the plumule, 1·75 cm. long including the sheath.

Stem herbaceous, forming a short, persistent, fleshy rootstock, with large, fleshy, tuberous or tuber-like roots, elongating when about to flower.

Leaves simple, radical and cauline, alternate, stipulate, petiolate, alternately penninerved in the young state and entire, but palmately five-nerved in the adult plant, glabrous in the seedling, but afterwards pubescent beneath; petiole semiterete, flattened above with obtuse edges, pale green, often stained with red, glabrous in seedling but pubescent in the adult; stipules none on the first leaf, or hidden in the sheath.

No. 1. Ovate-oblong, obtuse, subcordate at the base, somewhat scabrous at the margin.

Coccoloba uvifera, *Jacq.* (fig. 623).

Hypocotyl erect, terete, glabrous, rather stout and of about equal thickness all the way up, 4–6·8 cm. above the soil, pale green stained with red.

Cotyledons large, foliaceous, oblate or quadrangular, erosely truncate at the apex, or widely, shallowly and irregularly emarginate, shortly petiolate, coriaceous, bright green and shining above, paler beneath, trinerved from the base with the midrib again forked about the middle, making in all four principal nerves, the outer one of each pair incurving, the inner curving outwards, each pair meeting above; from these smaller ones are given off and anastomose throughout the lamina, which is 2·4–2·65 cm. long and 3–3·4 cm. wide; petiole flattened above or slightly grooved, convex on the back, minutely puberulous at the margin, connate at the base or produced into a stipuliform or ochreate sheath enveloping the plumule, 2·5 mm. long, with the sheath about 1·5 mm. long.

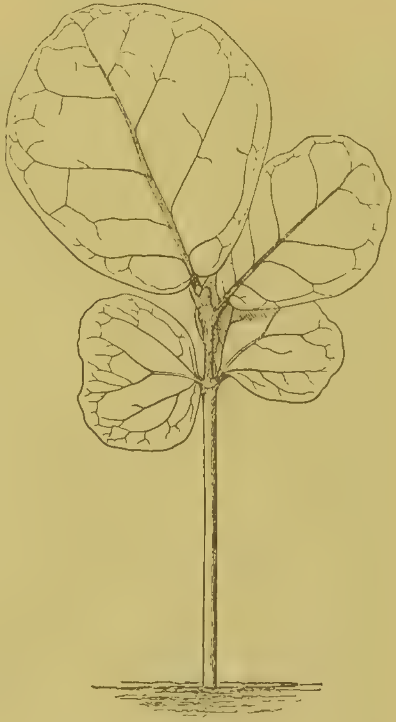

FIG. 623.—*Coccoloba uvifera.* Half nat. size.

Stem erect, terete, minutely puberulous, ultimately woody; 1st internode 1·3–1·4 cm. long; 2nd short, about 2–3 mm.

Leaves simple, cauline, alternate, stipulate, shortly petiolate, alternately incurvinerved, with the nerves uniting at their curved tips, reticulate, coriaceous, glabrous except the petiole, a deep shining green above, or in the young state more or less stained with red; stipules ochreate, forming a sheath round the stem, and in their youngest state a cap to the terminal bud, and after loosing the cap becoming truncate.

Petioles very short, semiterete, grooved above, minutely puberulous at the margins.

No. 1. Obovate, broad and obtuse at the apex, very shallowly sinuate or nearly entire, slightly cordate at the base.

No. 2. Rotund, obovate, much larger, broad and obtuse at the apex, obsoletely angled or almost entire at the margin, cordate at the base, with short rounded auricles.

ARISTOLOCHIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 121.

Fruit and Seed.—The ovary is inferior or rarely half-superior, consisting of four to six carpels cohering by their edges, with the placentas projecting into the cavity and making it imperfectly four- to six-celled, or cohering and forming as many complete cells. The ovules are indefinite in each cell, usually very numerous, horizontal or pendulous, superposed in one or two series and anatropous. The fruit is sometimes indehiscent, crowned with the persistent perianth, and liberating the seeds only by decay, or it is capsular with a deciduous perianth, dehiscing septicidally or breaking away from the placentas. The seeds are indefinite, often very numerous, horizontal or pendulous, immersed in a spongy cellular tissue arising from the endocarp, ovoid or oblong, obtusely trigonous, or compressed and flat or concave. The testa is crustaceous, rugose or smooth, with the raphe in plano-concave seeds fleshy and thickened or dilated. Endosperm is copious and fleshy. The embryo is minute, enclosed in the endosperm close to the hilum, oblong or ovoid, with the cotyledons closely applied to one another and about as long as the radicle.

Seedlings.—The cotyledons attain a comparatively large size during germination by feeding upon the endosperm. Those of Aristolochia caudata are broadly oblong, rounded and entire at either end, five-nerved at the base and strongly nerved upwards with alternate branching nerves. The lamina hangs perpendicularly from the apex of its horizontal petiole. The whole seedling of Aristolochia elegans (fig. 624) is smaller. The cotyledons are broadly oval, obtuse, emarginate, suddenly narrowed into the petiole, trinerved throughout their length and reticulate. The first pair of leaves are smaller than the cotyledons, for which they might be mistaken as they are nearly on the same level, suborbicular and emarginate, but they are trinerved at the base only with alternate nerves upwards. The following three leaves are broadly reniform and trinerved with copiously branching nerves.

Aristolochia caudata, *L.*

Root short, oblique, slightly branching.

Hypocotyl about 6 cm. long, 2 mm. thick, terete, glabrous, herbaceous, green.

Cotyledons with shallow channelled, glabrous, horizontal petioles and vertically reclinate or pendent blade 2·5 cm. long, 2 cm. wide, oblong, rounded, entire, penninerved, glabrous, thin, deep glaucous-green above, paler beneath.

Stem.—1st internode 2 mm. long and as thick; 2nd twice as long, but thinner than the first, terete, slightly pubescent, green.

Leaves simple, cordate at the base, otherwise entire, cauline, alternate (the first two opposite), exstipulate, petiolate, glabrous, glaucous-green above, paler beneath; petiole somewhat pubescent.

Nos. 1 and 2. Opposite, long petioled, reclinate, with a blade 3 cm. long, 2·5 cm. wide, subcordate, acute, subpalmatinerved, reticulate, entire, quite glabrous, deep glaucous-green above; petiole 3 cm. long, 1·5 mm. wide, slightly pubescent.

Nos. 3, 4, &c. Alternate, broadly cordate through the appearance of a small veinlet and accompanying parenchyma at the base of the lowest vein of each of the two basal primary nerves.

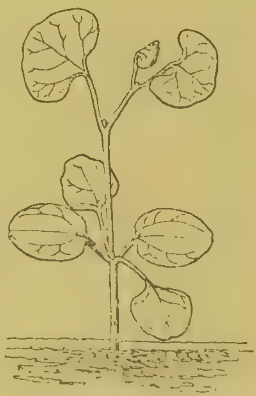

FIG. 624.
Aristolochia elegans.
Nat. size.

Aristolochia elegans, *Masters* (fig. 624).

Hypocotyl erect, terete, slender, glabrous, 8–10 mm. above the soil.

Cotyledons broadly oval, obtuse, minutely emarginate, suddenly tapering into the petiole, foliaceous, membranous, glabrous, trinerved with the lateral ones giving off short branches on their outer sides; lamina 8–9 mm. long, 6·5 mm. wide; petiole slender, channelled above, 2·5 mm. long.

Stem erect, terete, slender, glabrous, ultimately climbing; 1st internode undeveloped; 2nd 1·2–1·3 cm. long.

Leaves simple, cauline, alternate except the first pair, entire, glabrous, petiolate, exstipulate; petiole slender, subterete, channelled above.

Nos. 1 and 2. Opposite, suborbicular, minutely emarginate, rather truncate at the base, petiolate, much smaller than the cotyledons and resembling them, but having more the venation of a foliage leaf.

Nos. 3-5. Reniform or broadly reniform, entire, trinerved, with all three nerves branching rather copiously, reticulate, glabrous.

PIPERACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 125.

Fruit and Seed.—The ovary is superior, sessile or rarely stipitate, consisting of three to four many-ovuled carpels, distinct or united at the base, or is one-celled and one-ovuled. The ovule is solitary and erect, or there are several ascending and orthotropous. The fruit is small and capsular in genera having numerous carpels, or it breaks up into three to four cocci or follicles; in genera where it is one-ovuled it is baccate and indehiscent, with a succulent or thin and almost dry pericarp. The seed or seeds according to the number present are globose, ovoid or oblong. The testa is membranous or thinly fleshy, rarely coriaceous. Both perisperm and endosperm are present and farinaceous. The former is copious and occupies the greater part of the seed, is often snowy-white and in many cases hardened at the periphery. The endosperm forms a small mass embedded in the perisperm close to the superior micropyle, distant from the hilum, and encloses the minute embryo. The cotyledons are short, often not very distinct; and the radicle is superior. A few exceptional cases occur as in Saururus and Lactoris where the fruit breaks up into cocci. The fruit is one-celled and opens at the top in

Houttuynia. In the genus Lactoris, where perisperm is comparatively scanty, it is oily rather than farinaceous.

Seedlings.—The embryo is very small while in the seed, but attains a relatively large size during germination, and the cotyledons assume somewhat the form of the seed. In Piper celtidifolium (fig. 625) they are broadly triangular, cuspidate, truncate at the base or inclined to cordate, membranous, and faintly trinerved. The first leaf is cordate and five-nerved, with strong sheaths at the base of the petiole. The next two are more elongated and more deeply auricled at the base, but otherwise similar. The hypocotyl of Peperomia fernandeziana is short and fleshy. The cotyledons are ovate, cuspidate and fleshy with no apparent venation. The stem is also fleshy. The first two leaves are oval or sometimes obovate, followed by three which are oblong and gradually larger.

Piper celtidifolium, *Hamilt.* (fig. 625).

Hypocotyl erect, terete, glabrous, 5–8 mm. long.

Cotyledons broadly triangular, obtusely cuspidate, petiolate, rather indistinctly trinerved, and reticulate, membranous, glabrous, truncate at the base or faintly inclined to be cordate, 8·5–9·5 mm. long, 9·5–10·5 mm. wide; petiole slightly channelled above, 4 mm. long.

Stem erect, terete, somewhat zigzag from node to node, glabrous, somewhat striate; 1st internode undeveloped; 2nd 6·5 mm. long.

Leaves simple, entire, cauline, alternate, exstipulate, petiolate, three- to five-nerved from the base, and reticulate, glabrous; petioles channelled above, sheathing the stem at the base, glabrous.

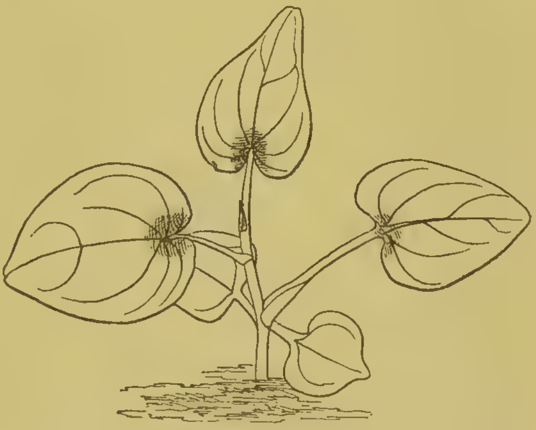

FIG. 625.—*Piper celtidifolium.* Nat. size.

No. 1. Cordate, obtuse, entire.

Nos. 2 and 3. More elongated and more deeply auricled at the base.

Peperomia fernandeziana, *Miq.*

Hypocotyl short, fleshy, tapering downwards, glabrous, marbled with red on a pale green ground, 3–6 mm. long.

Cotyledons ovate, cuspidate, subacute, petiolate, glabrous, fleshy, without apparent venation, pale green; lamina 4 mm. long, 3 mm. wide; petiole 1–1·25 mm. long.

Stem somewhat fleshy, erect, terete, red, thinly hairy with woolly hairs; 1st internode 2–3·5 mm. long, or sometimes scarcely developed; 2nd 1–7·5 mm. according to the strength of the plant.

Leaves simple, entire, cauline, alternate, sometimes opposite, exstipulate, petiolate, glabrous, fleshy, opaque above with the three nerves scarcely discernible, silvery white beneath and distinctly trinerved; petioles shallowly channelled above, thinly woolly, hairy, narrowed to their insertion at the base.

Nos. 1 and 2. Oval, obtuse, or sometimes subobovate.

Nos. 3–5. Oblong, obtuse, gradually larger.

PROTEACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 165.

Fruit and Seed.—The ovary is superior, apocarpous, one-celled, oblique or excentric, with one, two, or several ovules. The ovules are collateral when geminate, rarely almost superposed, or numerous and superposed in two series, sometimes inserted on or close to the apex, and superposed, sometimes laterally affixed, amphitropous, or almost anatropous, ascending from the base or descending, with the micropyle always inferior. The fruit is nutlike or drupaceous, and indehiscent, sometimes dehiscing at last along the inner margin or at the apex, like a follicle or capsule. The seeds are solitary, twin or few, flattened, compressed or thickened. The testa is membranous or coriaceous, and often winged in a variety of ways. Endosperm is wanting. The embryo conforms in shape to the seed excepting the wing when that is present. The cotyledons are sometimes much flattened and equal, sometimes much thickened and unequal. The radicle is short, straight, and inferior or lateral, and often enclosed between the auricles of the cotyledons.

The Order is divided into two series according as the fruit is nut- or drupe-like and indehiscent; or dehiscent and capsular or follicular; but in the latter group there are some exceptions. The dry woody fruits may hang on the plants for years before bursting open.

The fruit of Grevillea Hilliana is a woody, one- to two-seeded follicle, dehiscing by the separation of the two carpels. The seed (fig. 628) is oblate, or oval, laterally much compressed, winged all round and attached to the placenta by one edge. The chalaza is at the upper end of the portion containing the embryo, and the raphe pursues a circuitous course over the wing, and then recurves towards the hilum below the middle of one edge of the seed. The embryo occupies the whole of the interior, and has broadly obovate cotyledons tapering to the base where they are strongly auricled in order to accommodate the short radicle.

The fruit of Hakea acicularis is broadly ovoid, thick-walled and very woody, but dehisces by two valves when mature and dry. When two seeds are produced in a fruit, they are semi-obovoid by mutual pressure, gibbous on one side, and flat or slightly concave on the faces in contact. The testa is tuberculated and black, and is produced into a brown or black, membranous and perforated wing, along one side and round the apex of the seed. The wing is obliquely oblong-ovate, about 1·5 cm. long, and 1 cm. wide. The cotyledons are obovate, deeply auricled at the base, rather unequal in thickness owing to mutual pressure and the peculiar form of the seed.

Seedlings.—There is great variation among the cotyledons, due chiefly to the size and shape of the seed in which they are formed, and that again owes its shape to the cavity of the fruit and whether one or two seeds are present. A large number of them have cotyledons varying between roundly obovate and oblong-obovate, auricled at the base, sessile or subsessile, indented on one side or having a sinus which gives them a falcate appearance. The roundly obovate form is well represented by Hakea acicularis (fig. 631). The presence of the auricles is explained in the account of the seeds of Grevillea Hilliana. The leaves of Hakea acicularis are narrowly linear and acute; the first four are very short, and all are very much narrower than the cotyledons. In H. laurina the cotyledons are obovate and considerably smaller than those of the last.

The cotyledons of H. eucalyptoides are oblong-obovate and sometimes indented on the sides. The first five leaves are lanceolate, the two primary ones being opposite. The cotyledons of H. florida are obovate-oblong and subfalcate owing to the indentation on one side. The cotyledons of Grevillea Hilliana (fig. 629) are obovate, trinerved, much larger than those of Hakea laurina, but otherwise similar. In weak seedlings the second and third leaves are spathulate and trifid; but in strong seedlings the next three at least are cuneate, gradually tapering to a petiole-like base and more deeply trifid. The cotyledons of Stenocarpus salignus are oblong-obovate, trinerved, and differ slightly from the type in having shorter basal auricles which clasp the axis horizontally. The first leaf is elliptic and entire. Lambertia formosa (fig. 627) has obovate and emarginate as well as auricled cotyledons. The cotyledons of Leucospermum conocarpum (fig. 626) are also emarginate, but they are unsymmetrical especially towards the base. They are scarcely, if at all, auricled at the base, but a broad and short petiole-like piece forms a sort of ligule clasping the axis in the very early stages of the seedling. A third type occurs in Banksia australis (fig. 632) which has oblong obliquely emarginate cotyledons, drawn out at the base into narrow horizontal auricles.

The cotyledons of Grevillea punicea differ in being longer, sometimes obliquely emarginate, sessile and connate at the base or perfoliate. Those of G. linearis agree with the last except that they are entire.

A number of types occur in the Order which cannot be classified with any of the above. The cotyledons of Hakea multilineata *var.* grammatophylla are obovate, retuse or truncate at the apex, and auricled at the base.

The cotyledons of Protea mellifera are obovate, spathulate, entire, sessile, fleshy and not auricled at the base. The latter character is unusual in the Order. The cotyledons of a species of Roupala from Bogota are oblong-ovate, acute, trinerved at the base, petioled and not auricled; both the last characters are unusual as well as the acute apex.

The cotyledons of Banksia speciosa (fig. 633) are obovate-oblong, ascending, obliquely truncate and crenate at the apex, trinerved and auricled at the base with subulate auricles cohering with one another and causing the cotyledons to assume their ascending direction.

Protea mellifera, *Thbg.*

Hypocotyl stout, erect, terete, 3·5–4 cm. long, light green with a very slight reddish tinge.

Cotyledons thick, fleshy, obovate-spathulate, obtuse, entire, tapering to the base, but scarcely petiolate, glabrous, green, indistinctly one-nerved.

Stem erect, square, glabrous, herbaceous, ultimately woody; 1st internode 3–4 mm. long; 2nd 1–2 mm.; 3rd and 4th 3–4 mm.

First leaves simple, entire, cauline, alternate, spathulate or almost lanceolate, acute, glabrous, petiolate with the petiole somewhat decurrent on the stem, or subsessile, exstipulate, subglaucous, pinnatinerved.

Leucospermum conocarpum, *R. Br.* (fig. 626).

Hypocotyl firm, nearly terete, 2–4 cm. long, 4 mm. thick, glabrous, brownish-green.

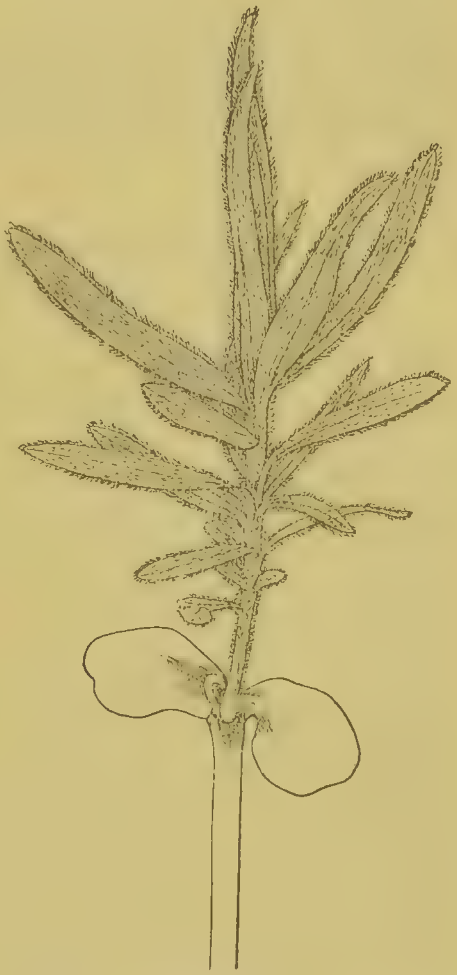

FIG. 626.—*Leucospermum conocarpum.* Nat. size.

Cotyledons sessile, 1·5–2 cm. long, 1–1·25 cm. wide, 2–3 mm. thick, unequal, obliquely oblong, obtuse, emarginate, otherwise entire, uneven with a broadly raised obscure midrib, and a thick ligule-like collar near the base clasping the young stem before the unfolding of the cotyledons, glabrous, yellowish-green above, pale beneath.

Stem with very short internodes, terete, 2–3 mm. thick, shortly pubescent at the base, densely so towards the apex, not very firm, light green.

Leaves simple, entire or nearly so, cauline, alternate, exstipulate, sessile, coriaceous, densely hairy or villous, and excepting the midrib with an indistinct venation.

Primary ones sessile, 1–5 cm. long, 3-10 mm. wide, scattered; first few small or aborted, acute, linear, entire with sunk midrib, pubescent like the stem, bright green, with the lower ones horizontal, the others twisted forty-five degrees or more from the plane of the axis of leaf, which itself is at an angle of forty-five degrees to the main axis.

Roupala sp. (*from Bogota*).

Hypocotyl erect, terete, glabrous, pale green, 7·5–10 mm. above the soil.

Cotyledons ovate-oblong, obtuse, or subacute, petiolate, with a few alternate, much ascending nerves, finely pubescent, light green above, paler beneath; lamina 1·2–1·35 cm. long, 4·5–5·5 mm. wide; petiole wide, grooved above, convex on the back, dilated and connate at the base, 2·5–3 mm. long.

Stem erect, flexuose, pale green, coarsely hairy or subvillous, ultimately woody; 1st internode 1·5–2·5 mm. long; 2nd 5–5·5 mm.; 3rd 6–7·5 mm.; 4th 3–8 mm.

Leaves in the seedling stage simple, cauline, alternate, exstipulate, sessile or shortly petiolate, alternately and ascendingly penninerved, hairy and scabrous on both surfaces, light green above, paler beneath, and somewhat shining, decurrent on the petiole when the latter is distinguishable; petiole when present short, deeply grooved or channelled above by the upturning of the edges, semi-amplexicaul, or often almost surrounding the stem.

No. 1. Obovate-cuneate, acutely serrate-dentate, with gland-tipped teeth, shortly petiolate.

No. 2. Similar, larger, wider, shortly petiolate.

No. 3. Similar, much larger, decurrent almost or quite to the base.

Nos. 4 and 5. Obovate-elliptic, much tapered to the base, irregularly and obtusely dentate or almost crenate, with the teeth tipped with an abruptly elongated gland or mucro.

Lambertia formosa, *Sm.* (fig. 627).

Hypocotyl erect, terete, pale green or red, glabrous, 9–15 mm. above the soil.

Cotyledons obovate and emarginate, or almost quadrangular, subsessile, shortly auricled at the base, thick, subrigid or coriaceous, glabrous, opaque, glaucous-green, ascending, more or less revolute longitudinally at the margin, 9–9·5 mm. long, 7–9 mm. wide, minutely and closely dotted with colourless spots.

Stem erect, terete, finely pubescent and hairy in the young state, scaberulous, pale green; 1st internode undeveloped or varying up to 4 mm. long; 2nd 4–7 mm.; 3rd 6·5–8·5 mm.; 4th 6–11 mm.

Leaves simple, entire, cauline, opposite or in whorls of three or four, decussate, exstipulate, sessile, finely reticulate on each side of a strong midrib, sunk on the upper and prominent on the under surface, even or undulate at the margin, and always slightly revolute there, horizontal, light green above, paler beneath, hairy when young and shortly and densely glandular-pubescent, glabrescent.

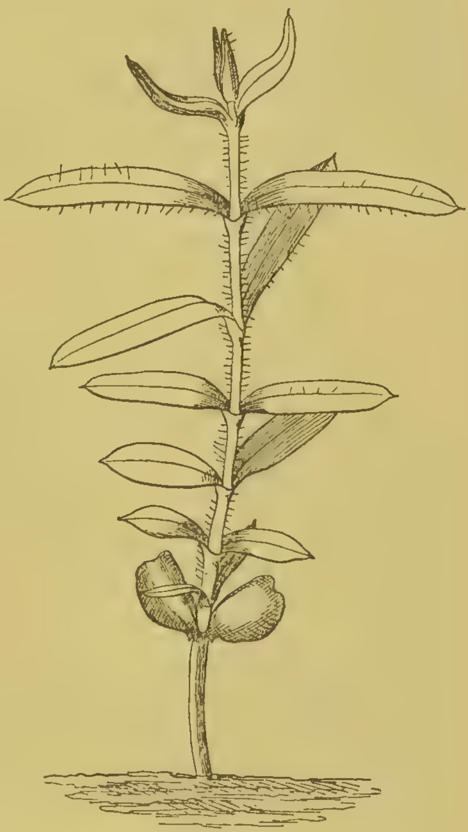

Fig. 627.—*Lambertia formosa.* Nat. size.

First and second pairs generally lanceolate, acute.

Third to ninth pairs linear-acute, cuspidate or bristle-tipped, slightly tapered to the base.

All these figures and descriptions are very liable to variation. Sometimes the third to seventh pairs are much shorter, wider, lanceolate and cuspidate.

The same numbers may be in whorls of three or four, or they may not be verticillate till the eighth or other higher nodes are reached.

Grevillea Hilliana, *F. Muell.* (fig. 628).

Ovary of one carpel, one-celled, with two laterally affixed amphitropous ovules.

Fruit a woody follicle, dehiscing when mature with two valves, one-celled, one- to two-seeded.

Seed oblate or oval, 1·6–1·8 cm. long by 9–10 mm. wide, ·25–·5 mm. thick, obtuse at either end, much compressed laterally; testa membranous, brown, dilated into a moderately broad wing all round; tegmen very thin, membranous, pale-coloured; micropyle at one end and chalaza at the other, but within the wing; hilum on one side below the middle; raphe visible as a dark line passing from the micropyle along one side of the wing and curved round to the chalaza at the apical end of the embryo.

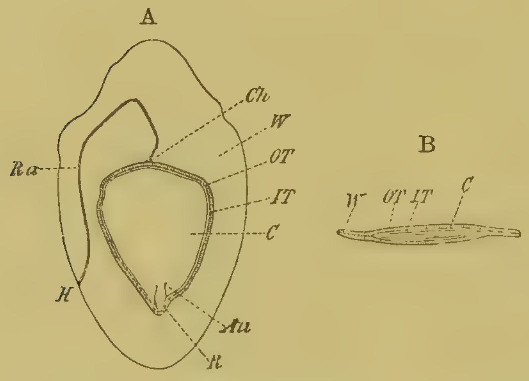

Fig. 628.—*Grevillea Hilliana*, × 2. A, longitudinal section of the seed: *H*, hilum; *Ra*, raphe; *Ch*, chalaza; *W*, wing; *OT*, testa; *IT*, tegmen; *C*, cotyledon; *Au*, auricle; *R*, radicle. B, transverse section: *W*, wing; *OT*, testa; *IT*, tegmen; *C*, cotyledon.

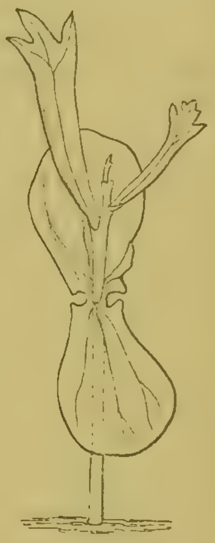

Fig. 629.
Grevillea Hilliana.
Nat. size.

Endosperm none.

Embryo large, straight, filling the cavity of the seed, colourless; cotyledons broadly obovate, truncate, nearly or quite flat, tapering to a cuneate base, and having unequal ovate acute auricles on each side of the radicle, lying in the broader plane of the seed with their edges to the placenta, and closely applied to each other face to face, exactly opposite or with the laminæ oblique to one another; radicle shortly fusiform, tapering to a subacute point, projecting a short way beyond the cotyledons and many times shorter.

Seedling (fig. 629).

Hypocotyl woody, erect, terete, pubescent with adpressed upturned, brown hairs, 2·3–2·9 cm. long.

Cotyledons sessile, obovate, rounded at the apex, auricled at the base and connate, forming a line round the stem, trinerved, ascending, coriaceous, deep green above and shining, paler beneath, glabrous.

Stem like the hypocotyl; 1st internode 3·5 mm. long; 2nd 2 mm.; 3rd 4·5 mm.; 4th and 5th each 3 mm.

Leaves cauline, simple, alternate, exstipulate, sessile.

No. 1. Always very small, often deformed or linear-oblong, obtuse, mucronate.

Nos. 2 and 3. Cuneate, and tapering to a long petiole-like base, deeply trifid and trinerved in the upper half, glabrous above, deep green and shining, paler beneath, and pubescent with white, upturned, adpressed silky hairs; lobes oblong, acute, or mucronate.

Grevillea linearis, *R. Br.* (fig. 630).

Hypocotyl erect, terete, woody, about 8 mm. above the soil.

Cotyledons oblong, obtuse, entire, sessile, connate at the base and appearing perfoliate, horizontal when full grown, about 8 mm. long, and 4 mm. wide above the middle.

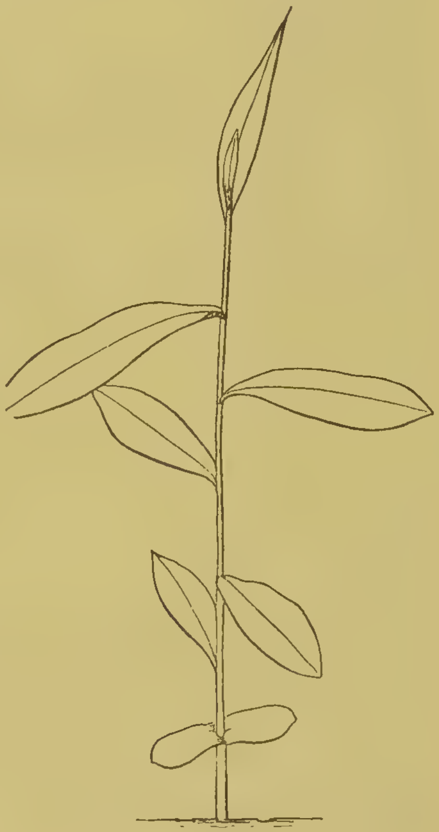

FIG. 630.—*Grevillea linearis.* Nat. size.

Stem erect, terete, woody; 1st internode 7·5 mm. long; 2nd 9 mm.; 3rd 1 cm.

Leaves simple, entire (at least in the early condition of the plant), cauline, alternate, exstipulate, sessile, coriaceous, thinly hairy, light green.

The seedling of **Grevillea punicea**, *R. Br.*, is very similar to that of G. linearis.

Hakea acicularis, *R. Br.*

Ovary shortly stipitate, of one carpel, one-celled, three- to four-ovuled in specimens examined; ovules parietal on the ventral suture, erect or ascending, anatropous; micropyle inferior.

Fruit a follicle, broadly ovoid, generally if not always laterally constricted near the apex, more or less deeply furrowed along the ventral suture, surface very uneven with protuberances and cavities, glabrous, the rough epidermis often reticulated with cracks and sometimes falling off in laminæ, dehiscing when mature along both sutures, exposing one or generally two seeds, and showing the walls of the fruit to be very thick and bony, with a layer of white, clean, close-grained wood all along the dorsal suture, which splits with a nearly even, clean fracture. This layer of wood causes the fruit to be of very unequal thickness, the dorsal wall being much the thicker.

Seeds when geminate, semiobovoid, very rough, tuberculated and gibbous on one side, flat or slightly concave on that towards the other seed, glabrous, black, obliquely winged along the ventral edge and round the apex where it is produced sometimes to the length of 1·5 cm. and 1 cm. in width, and narrowed to an obtuse point, thin, membranous and perforated or reticulated, deep brown, almost black; hilum and micropyle basal at the ventral suture of the follicle, contiguous; raphe and chalaza indeterminable in the mature seed.

Endosperm absent.

Embryo very large, filling the seed and conforming to it in shape, straight, colourless, rather fleshy; cotyledons obovate, broadly rounded at the apex, rather deeply auricled at the base, otherwise entire, unequal in thickness, one being flat or slightly concave on the side next the other seed, while the other next the side of the follicle is convex or gibbous to correspond to the cavity in the follicle, and somewhat depressed into little holes or cavities; radicle very short, turbinate, obtuse, scarcely protruding beyond the auricles of the cotyledons and pointing into the narrow base of the seed.

Seedling (fig. 631).

Hypocotyl erect, terete, stout, glabrous, crimson or deep dull red, 2·3–2·8 cm. long.

Cotyledons obovate-rotund; apex entire, acutely auricled at the base, thick, fleshy, glabrous, subsessile, deep green above, paler beneath, faintly five-nerved on the under side but venation otherwise indiscernible, often slightly unequal with about 1 mm. difference in length and width, 1·5–1·2 cm. long, and the same at the widest part, tapering downwards to the radicle; petiole ·25–·5 mm. long.

Stem erect, terete, glandular-pubescent, pale green, becoming red, and soon becoming frutescent; 1st internode 9–12 mm. long; 2nd 0–1 mm.; 3rd and all succeeding internodes very short and irregular in length, from 0–4 mm. long, seldom more.

Leaves simple, entire, cauline, alternate, exstipulate, sessile, terete or acicular, acute or tipped with a small reddish spine, glabrous except in the shallow furrow corresponding to the midrib beneath, where they are somewhat glandular-pubescent, slightly decurrent at the very base, densely covered with minute colourless points.

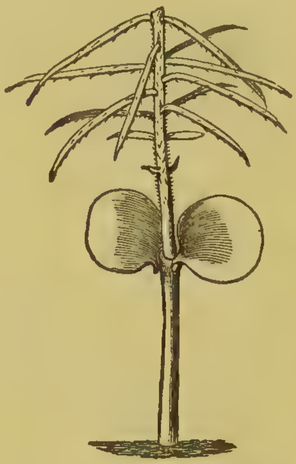

FIG. 631.—*Hakea acicularis.* Half nat. size.

Nos. 1–4 and sometimes 5. Small, subulate, acute, or the 4th and 5th linear.

No. 6 and upwards. Gradually longer, acicular.

Hakea laurina, *R. Br.*

Hypocotyl more slender than in H. acicularis, 3·3–4·5 cm. above the soil.

Cotyledons very similar to those of H. acicularis but smaller, longer in proportion and shortly petiolate, light green, opaque, with faint indications of three nerves on the under side; lamina 7–9 mm. long, 6–7·5 mm. wide; petiole semiamplexicaul, somewhat grooved above, slightly convex or nearly flat beneath, ·5–1 mm. long.

Stem erect, terete, shrubby, glabrous, reddish, slightly flexuose at least in the young state; 1st internode 4–6 mm. long; 2nd undeveloped; 3rd 5–7 mm.; 4th 4–5 mm.

Leaves simple, cauline, alternate (first and second opposite), exstipulate, sessile and narrowed to the base (at least in the young state), alternately, ascendingly incurvinerved, glaucous on both surfaces with a sparse ascending adpressed pubescence (each hair fixed by its middle); petioles none.

Nos. 1 and 2. Opposite, lanceolate, acute, semiamplexicaul at the base, concave above or boat-shaped, ascending or suberect.

Nos. 3 and 4. Spathulate-oblong, acute, entire, spreading longitudinally.

Nos. 5–8. Oblanceolate, tapering to the base, much larger than those below them, deep glaucous-green with a reddish entire margin, ascending or spreading horizontally, or by a slight twist of the base turned with their edges more or less vertical.

Hakea eucalyptoides, *Meisn.*

Hypocotyl as in preceding species, 1·5–3 cm. long.

Cotyledons very like those of H. acicularis, light green, indistinctly one-nerved and rather unequal.

Stem erect, terete, herbaceous, with a few rather long hairs, ultimately woody; 1st internode 4–10 mm. long; 2nd 3–7 mm.; 3rd 6–12 mm.

First leaves lanceolate, very similar to those of H. laurina, with a few rather long silky hairs.

Hakea florida, *R. Br.*

Hypocotyl short, ·75–2 mm. long, light green or colourless.

Cotyledons thick, fleshy, obovate-oblong, obtuse, entire or falcate, cordate at the base, sessile, glabrous, light green, rather unequal, indistinctly one-nerved.

Stem erect, terete, herbaceous, ultimately woody, pubescent; 1st internode 1–2 mm. long; 2nd 1–2 mm.; 3rd 5–6 mm.

First two leaves very small; others oval-oblong, mucronate, dentate, subsessile, pubescent, light green, trinerved.

Hakea multilineata, *Meisn.*, *var.* grammatophylla.

Hypocotyl erect, terete, green, soon becoming brown, woody with the epidermis becoming rent and thrown off, slightly pubescent, glabrescent, 1·8–2·5 cm. above the soil.

Cotyledons cuneate, sessile, truncate or retuse at the apex, tapered towards the base and slightly auricled, thinly pubescent on both surfaces and pale green, thick and subcoriaceous, 9·5–11 mm. long, 5·5–7·5 mm. wide near the apex, no venation discernible.

Stem erect, terete, somewhat pubescent or hairy, pale green soon becoming brown; 1st internode 4–7 mm. long; 2nd 1–2 mm.; 3rd 7–10 mm.; 4th 5·5–7 mm.

Leaves sessile, or a few primary ones tapered to a short petiole, trinerved from near the base, the nerves again giving off strong, ascending branches in the broader leaves, reticulate, pubescent on both surfaces with adpressed whitish hairs, subglabrescent, coriaceous, thickened or somewhat cartilaginous at the margin, glaucous-green above and paler beneath in the lower leaves, but coloured equally in the upper leaves which become vertical by a twist close to their base.

Nos. 1–4. Oblanceolate, acute or cuspidate, horizontal, tapered to a narrow base, rather small.

Nos. 5 and 6. Obovate-oblong, cuspidate, obtuse, horizontal, tapered to a semiamplexicaul base, densely pubescent at the margin near the base with spreading short hairs besides the adpressed scattered hairs.

No. 7. Vertical or horizontal, otherwise like No. 6.

Nos. 8 and 9. Narrower, more acuminate, vertical.

Stenocarpus salignus, *R. Br.*

Hypocotyl erect, quadrangular, glabrous, light green, almost colourless near the soil.

Cotyledons broadly obovate-oblong, obtuse, entire, sessile, with pointed auricles, rather thick, glabrous, green, trinerved, each nerve with numerous veinlets.

Stem erect, quadrangular, rather downy; 1st internode very short.

Banksia australis, *R. Br.* (fig. 632).

Hypocotyl woody, erect, terete, glabrous, green, soon becoming grey, about 1·2 cm. above the soil.

Cotyledons oblong, obtuse, obliquely emarginate, sessile, glabrous, pale green, coriaceous, drawn out into a slender horizontal auricle at the base, 8 mm. long, 5 mm. wide.

Stem woody, erect, terete, densely covered with interlacing white hairs when young, and less so or becoming glabrous as it gets old, pale green becoming brown; 1st and 2nd internodes undeveloped; 3rd 4 mm. long; 4th 4·75 mm.; 5th 3·5 mm.; 6th 1·5 mm.; 7th 1 mm.; 8th ·5 mm.

Leaves simple, cauline, alternate or opposite or by the suppression of the internodes verticillate or subverticillate, exstipulate, thinly felted with white hairs above and a white tomentum beneath, coriaceous; petioles short, channelled above, thickened at the base.

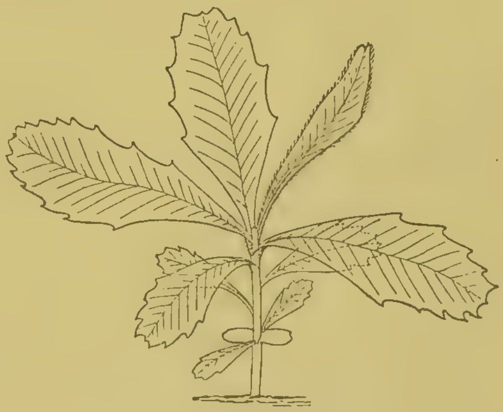

FIG. 632.—*Banksia australis.* Half nat. size.

Nos. 1 and 2. Opposite, cuneate, serrate-dentate above the middle, 1·7 cm. long.

No. 3. Oblanceolate, tapering to the base, serrate-dentate above the middle and tridentate at the apex ; teeth spinous.

No. 4. Narrowly obovate-cuneate, otherwise like the last.

No. 5. Similar, but larger.

No. 6. Obovate, cuneate at the base, otherwise like No. 3.

Nos. 7 and 8. Similar, but larger ; No. 8, 6·9 cm. long.

Banksia speciosa, *R. Br.* (fig. 633).

Hypocotyl erect, terete, glabrous, stoutest under the cotyledons, deep reddish-crimson, 2–2·5 cm. above the soil.

Cotyledons obovate-oblong, obliquely truncate and crenate at the apex, with almost straight and nearly parallel sides, slightly tapered to the base where they are auricled with subulate, acute, slightly declining auricles connate with those of the other cotyledon, tri-nerved, nerves incurved and uniting with one another some distance below the apex, deep opaque green above, paler beneath or tinged with violet, glabrous, sessile, 1·5 cm. long on one side and 1·35 cm. on the other, 1·2 cm. wide at the apex, 6 mm. at the base exclusive of the auricles.

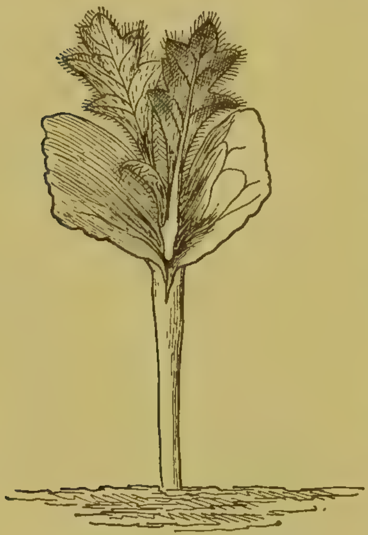

Fig. 633.—*Banksia speciosa.* Nat. size.

Stem erect, terete, hairy, reddish when young, ultimately shrubby; 1st and 2nd internodes rather compressed, about ·5 mm. long.

Leaves alternate, alternately and ascendingly penninerved, deep green above and densely hairy or almost villous, white with tomentum beneath, revolute at the margins; petiole semiterete, flattened above, densely hairy with jointed hairs, somewhat margined above by the decurrent base of the lamina.

Nos. 1 and 2. Cuneate, pinnatifid with two, rarely three, triangular, obtuse, ascending coarse teeth or lobes on each side.

THYMELÆACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 186.

Fruit and Seed.—The ovary is superior, one-celled and one-ovuled, or in the tribes Phalerieæ and Aquilarieæ two-celled with one ovule in each cell. The ovule is inserted laterally near the apex of the cavity, pendulous and anatropous with a ventral raphe. The fruit is nut-like, baccate, or drupaceous and indehiscent, except in the tribe Aquilarieæ. The seed is solitary, pendulous or laterally fixed. The testa is coriaceous or rarely membranous, with a distinct membranous inner layer. Endosperm is copious or scanty and fleshy or altogether wanting. The embryo is straight, and large, with fleshy, often thick cotyledons, while the radicle is short and superior. Exceptions from the above characters occur in two anomalous genera, Octolepis consisting of a single species with a four-celled ovary containing one ovule in each cell; and Gonystylus with a four- or five-celled ovary, each cell with one ovule.

A type of the Order is represented by Daphne Mezereum. The seed is obovoid, pendulous and attached to the placenta by a broad flattened funicle near the apex. The tegmen is very thick, while the endosperm is reduced to a thin layer investing the large fleshy embryo. The cotyledons are plano-convex, and slightly auricled at the base, where the short stout radicle is situated.

Daphne Mezereum, *L.*

Ovary of one carpel, one-celled, one-ovuled; ovule pendulous from near the apex of the cell, anatropous; micropyle superior.

Fruit a berry, ovoid or subglobose, glabrous, green but becoming scarlet as it matures, and shining, one-celled, one-seeded; epicarp and endocarp thin; mesocarp juicy or pulpy and orange-yellow or scarlet.

Seed obovoid, suspended by a short funicle from near the apex of the cell, glabrous, closely conforming to the interior of the berry; testa thin, membranous, pale-coloured, easily detached from the much thicker and subcrustaceous tegmen, deep brown, almost black and shining when fresh, but dull brown when dry; raphe forming a conspicuous white line along the ventral side of the pale testa; chalaza apical and inferior, conspicuous, pale-coloured, yellowish-white; hilum and micropyle contiguous, basal to the seed and superior.

Endosperm in the mature seed very scanty, forming an extremely thin yellow film or membrane over the embryo resembling a third coating of the seed, with a thicker, whiter (yellow when dry), fleshy ring around the radicle.

Embryo comparatively very large and almost filling the seed, straight, fleshy, colourless; cotyledons hemispherical or more often semiovoid, strongly plano-convex, minutely auricled at the base, otherwise entire, each occupying half of the seed, lying with their backs to the raphe, and consequently to the placenta, or slightly obliquely to it; radicle very short, turbinate, obtusely pointed, protruded about one-half to two-thirds its length beyond the auricles of the cotyledons, and lying in the subacute tip of the seed, surrounded by a thickish layer of endosperm, and close to the micropyle.

ELÆAGNACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 203.

Fruit and Seed.—The ovary is superior but enclosed in the base of the perianth, and is one-celled, one-ovuled. The ovule is basal, erect and anatropous. The fruit is enclosed in the persistent base of the perianth which becomes thick, fleshy and ultimately baccate, resembling in outward appearance a true berry. The wall of the fruit proper is thin, membranous and entirely filled by the large solitary seed. The testa of the latter is thickened, and crustaceous or hardened. The endosperm is very scanty, and membranous, usually most abundant around the radicle, or it may be altogether wanting. The embryo is large, straight, conforming to the seed, with thick and fleshy plano-convex cotyledons, and a very short, stout, inferior radicle.

The seed of Hippophaë rhamnoides is obovoid, slightly notched at the basal hilum, and surrounded by a depressed line, apparently caused by a ridge in the pericarp during the early stages of growth. The testa is of great thickness, hard and shining black. The embryo conforms to the seed and is only surrounded by a thin film of endosperm except around the radicle, where endosperm is necessary to fill the space owing to the shortness of the auricles of the cotyledons. In the early growing state of the fruit, the persistent base of the perianth grows at a rate proportionate with that of the ovary which completely fills it. The testa is of great thickness; the tegmen covers a thick layer of perisperm, then follows a thicker layer of endosperm in the embryo-sac, and only slightly shorter than the perisperm just before the fruit attains its full size. The embryo at this stage is half as long as the endosperm, with broadly oval, thin plano-convex cotyledons. The radicle is relatively long compared with the cotyledons. The perisperm and most of the endosperm disappears when the embryo reaches its full size. The neck of the persistent perianth is lined with hairs internally.

The baccate perianth of Elæagnus longipes is broadly oblong-oval and densely lined all over the internal surface with interlacing, strong, cottony hairs. The inner layer of the perianth is also hardened, bony, and strengthened with numerous longitudinal woody ridges forming a complete circle surrounding the true fruit which conforms to the cavity. The seed is ellipsoid in conformity with the fruit, and has a membranous testa. The cotyledons are lanceolate, obtuse, deeply auricled at the base, so as to occupy the space around the radicle, plano-convex, and completely fill the seed, endosperm being altogether absent.

Seedlings.—The cotyledons of Hippophaë rhamnoides (fig. 635) are oblong, obtuse, entire in the early stages but ultimately more or less distinctly and irregularly emarginate, sessile, or very shortly petiolate, slightly auricled at the base, fleshy, aerial, somewhat plano-convex and glabrous. The leaves are opposite in the seedling stage, the first pair being lanceolate, followed by three or more pairs which are elliptic and obtuse. All are covered with shortly stalked, peltate scales; on the adult the leaves are alternate.

The cotyledons of Elæagnus angustifolia *var.* microcarpa (fig. 634) are oblong, obtuse, deeply auricled at the base but otherwise entire, thick and fleshy with indiscernible venation.

They differ from those of Hippophaë rhamnoides in being more deeply auricled at the base, but more especially in having semiterete petioles 4–9 mm. long. The first four leaves are lanceolate-oblong, penninerved and covered with stellate scales. The first two are opposite, the rest alternate; this is also the case sometimes with Elæagnus hortensis, where the first two are lanceolate; the cotyledons exhibit an indistinct midrib, but are otherwise similar to those of the last-named species, except that the petioles are shorter.

Elæagnus longipes, *A. Gray.*

Fruit an achene, enclosed in the fleshy or baccate perianth, furnished with stellate scales that do not cover the whole surface, yellow or nearly scarlet when mature; middle layer of perianth juicy or pulpy; inner layer hardened or bony and strengthened with numerous longitudinal, strong, thickened ridges, and covered on the inner face with a dense interlacing layer of tough cottony hairs; pericarp thin, membranous, tipped with the remains of the style, pale-coloured.

Seed ellipsoid, rather narrow, conforming to the interior of the ovary, which again conforms to the interior of the calyx-tube; testa thin, membranous, whitish; raphe passing along the whole length of the seed and forming a conspicuous ridge; funicle short; chalaza apical and superior, conspicuous; hilum and micropyle basal, inferior, contiguous.

Endosperm absent.

Embryo straight, large and occupying the whole interior of the seed, colourless; cotyledons lanceolate or oblong, obtuse, rather deeply auricled at the base, otherwise entire, plano-convex and each occupying half of the seed, lying with their edges to the raphe (in all the specimens examined); radicle oblong or ellipsoid, obtuse, about half its length protruded beyond the auricles of the cotyledons and much shorter than the latter, occupying the narrow base of the seed.

Elæagnus angustifolia, *L., var.* microcarpa (fig. 634).

Hypocotyl erect, terete, glabrous, rarely with a few stellate scales, pale green, 3–3·5 cm. above the soil.

Cotyledons oblong, obtuse, entire at the apex and rounded, deeply auricled at the base, thick, fleshy, with indiscernible venation, somewhat shining, pale opaque green above, bright green beneath, mostly glabrous or with stellate scales on the petioles; lamina 1-

1·35 cm. long, 5–7 mm. wide; petioles semiterete, slightly grooved above, tapering slightly upwards, pale green, 4–9 mm. long.

Stem erect, terete, densely covered with stellate or radiate scales, ultimately shrubby; 1st internode 6–9·5 mm. long.

Leaves simple, entire, cauline, alternate (first two opposite or nearly so), exstipulate, petiolate, alternately and ascendingly penninerved, densely covered beneath with stellate scales, and on the upper side at least in the seedling; petioles short, semiterete, slightly grooved or merely flattened above, densely stellate-scaly like the leaves.

Nos. 1–4. Lanceolate-oblong, acute or obtuse, alternately and ascendingly penninerved, with few and indistinctly visible nerves incurving and uniting in a single intramarginal wavy line.

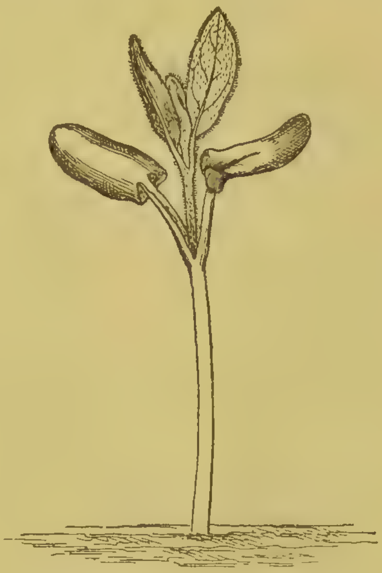

FIG. 634.—*Elæagnus angustifolia* var. *microcarpa*. Nat. size.

The seedling of **Elæagnus hortensis**, *M. B.*, closely resembles the preceding.

Hippophaë rhamnoides, *L.*

Fruit enclosed in the baccate perianth; pericarp thin, membranous, pale-coloured, traversed along two sides with a thickened yellow nerve or ridge uniting beneath the persistent style and also at the base of the seed, one-seeded, indehiscent. The baccate perianth becomes enlarged at the base, and globular, ultimately fleshy, pulpy or almost deliquescent internally.

Seed obovoid, marked on two sides with a vertical depressed line caused by the ridges on the pericarp, slightly unequal at the base; testa very much thickened and hardened, shining black, smooth; hilum basal between the unequal lobes of the emarginate base.

Endosperm in the mature seed forming a very thin layer on the inner surface of the testa, except at the base where it forms a thick sheath round the radicle.

Embryo straight, large, subobovoid, fleshy, occupying almost the whole of the seed; cotyledons plano-convex, closely occupying the interior of the seed, slightly auricled or cordate at the base; radicle short, stout, subturbinate, obtuse, embedded in a thick layer of endosperm, close to the hilum and pointing into the longer lobe of the seed at the base of the fruit.

Seedling (fig. 635).

Hypocotyl erect, terete, pale green, glabrous, about 1·7–2·6 cm. above the soil.

Cotyledons oblong, obtuse, entire or minutely and irregularly emarginate, slightly auricled at the base, somewhat plano-convex, fleshy, glabrous, dull green above, light green beneath and somewhat shining, very shortly petiolate, with indistinguishable venation, or a midrib discernible in a younger state; lamina 7–8·5 mm. long, 4·5–5·5 mm. wide; petiole 1–1·25 mm. long.

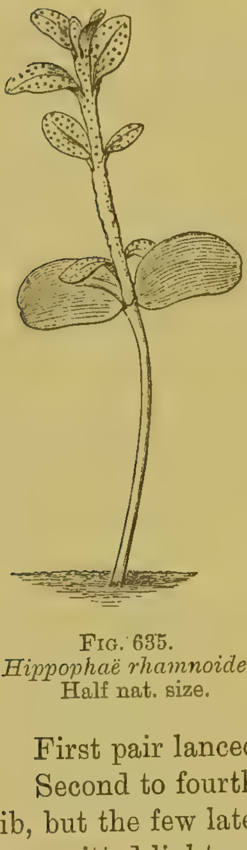

FIG. 635.
Hippophaë rhamnoides.
Half nat. size.

Stem erect, terete, pale green, rough or scurfy with scales, ultimately woody; 1st internode 3 mm. long; 2nd 7 mm.; 3rd 3·75 mm.

Leaves simple, entire, cauline, alternate (opposite in the seedling state), exstipulate, shortly petiolate, covered with very shortly stalked scales, giving the leaves a silvery appearance on both surfaces, somewhat fleshy and opaque in the seedling stage, alternately penninerved; petiole channelled on the upper side, convex on the back, silvery like the lamina, 1 mm. long in the seedling.

First pair lanceolate, obtuse, with the midrib only discernible.

Second to fourth pairs elliptic, obtuse, showing a distinct midrib, but the few lateral nerves present are hardly discernible with transmitted light.

SANTALACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 217.

Fruit and Seed.—The ovary is inferior from the first, or becomes so during the flowering period, or in the tribe Antholeæ the disc only surrounds it at the base; in all cases it is one-celled. The ovules vary from two to three, and are pendulous from or near the apex of a central, filiform or thickened placenta; or in the Antholeæ the ovule is solitary, central, basal and erect.

The fruit is nut-like or often drupaceous, and is indehiscent. The exocarp is slender and dry, sometimes fleshy or succulent, sometimes thickened; while the endocarp is crustaceous, hardened or bony. The seed is globose or obovoid, and smooth, rugose, or deeply many-furrowed. The testa is very thin and not easily distinguishable, or is absent or apparently so. Endosperm is copious and fleshy, often white. The embryo is often oblique, not strictly central, short or linear, very often terete, and straight or scarcely incurved. The cotyledons are semiterete or rarely slightly dilated and longer or shorter than the superior radicle. Sometimes the embryo is minute and scarcely discernible.

Exceptional cases occur in Cervantesia and Santalum where the ovary is superior or rarely immersed in the disc. The endocarp is plicate, and in Henslowia is intruded into furrows of the seed. Santalum ellipticum may be regarded as typical of the Order. The fruit is obovoid-elliptic or subglobular and crowned by a rim, the persistent portion of the calyx. The exocarp is comparatively thin when dry, and the endocarp is thick and woody. The seed is ovoid, conforms to the interior of the cavity, and is apparently without a testa. The greater part of it consists of a mass of fleshy endosperm. The cotyledons are ovate-oblong, and in the specimen observed several times shorter than the radicle. The latter is very much thicker than the cotyledons at its base, and tapers to a slender point.

Seedlings.—The cotyledons of all the seedlings coming under my notice are narrowly linear. Those of Osyris compressa (fig. 636) are revolute at the edges and thus appear still narrower. They are 2–2·25 cm. long and 2–2·5 mm. wide. The leaves are opposite, decussate, very closely arranged and closely resemble those of a species of Buxus both in size, shape, texture and colour. The first two pairs are lanceolate-elliptic, followed by at least seventeen other pairs which are obovate, and generally cuspidate. The cotyledons of O. abyssinica are similar to those of the last and yellowish-green. The first pair of leaves are lanceolate and acute.

The seedlings of Santalum album are very similar to those of the foregoing with respect to the cotyledons and the mode of germination. The hypocotyl is elongated and in germinating carries up the fruit on the cotyledons. In the case of Santalum at least the cotyledons often have a difficulty in getting clear of the fruit notwithstanding their narrowness, and often become torn off in the process. Their narrowness appears to be due to the difficulty of exit from the small opening of the woody fruit; for there is plenty of space inside to allow of their attaining a much greater width.

Santalum ellipticum, *Gaud.*

Ovary inferior, one-celled, two- to three-ovuled; ovules pendulous, anatropous; micropyle superior.

Fruit a drupe, obovoid-elliptic, with four ridges at the base, and smaller intermediate ones, and as many prominences near the apex which is crowned with an annular rim, the persistent base of the perianth, within which it ends with a conical point; one-celled, one-seeded, indehiscent; exocarp comparatively thin; endocarp woody, pale-coloured.

Seed conforming to the cavity of the ovary, and apparently without a testa.

Endosperm copious, fleshy, white, constituting the greater part of the seed, wrinkled or furrowed longitudinally when dry.

Embryo straight, thin or narrow, less than half the length of the seed (probably imperfectly developed), yellowish; cotyledons ovate-oblong, obtuse, entire, sessile, several times shorter than the radicle, and narrower than its thickest part; radicle four to five times as long as the cotyledons, stout at the origin of the cotyledons and tapering to a long slender tip which lies immediately within the apex of the endosperm.

N.B.—In the fruit figured in Le Maout and Decaisne, p. 723, the long narrow cotyledons reach nearly to the base of the seed and are twice the length of the radicle.

Osyris compressa, *DC. fil.* (fig. 636).

Hypocotyl woody, erect, terete, glabrous, brown, 1·7–2 cm. above the soil.

Cotyledons linear, obtuse, rigid, with revolute margins, pale subglaucous-green, sessile, 2–2·25 cm. long, 2–2·5 mm. wide.

Stem woody, erect, terete at the base, quadrangular upwards, glabrous, pale yellowish- or subglaucous-green, ultimately brown; 1st internode 1·85 cm. long; 2nd 8·5 mm.; 3rd 1·1 cm.; 4th 5·5 mm.; 5th 5·5 mm.; 6th 4·5 mm.; 7th 6 mm.; 8th 7 mm.; 9th 1 cm.; 10th 9 mm.; 11th and 12th each 6·5 mm.; 13th and 14th each 6 mm.; 15th, 16th and 17th each 7·5 mm.

Leaves simple, entire, cauline, opposite, exstipulate, sessile, thick, coriaceous, glabrous, pale glaucous-green, almost yellowish, obscurely alternately penninerved.

First and second pairs lanceolate-elliptic, acute.

Third to seventh pair inclusive, obovate, obtuse, apiculate or minutely cuspidate, convex above and concave beneath.

Eighth to nineteenth pair inclusive, obovate, obtuse, minutely cuspidate, flat.

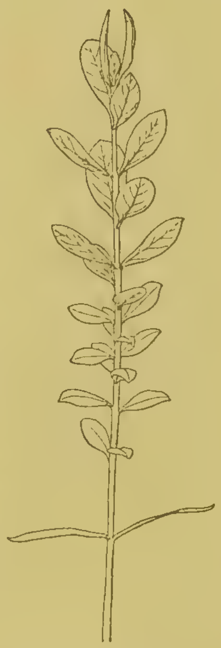

FIG. 636.
Osyris compressa.
Half. nat. size.

Osyris abyssinica, *Hochst.*

Hypocotyl stout, thickened considerably near the base, reddish, 2·5–2·6 cm. long.

Cotyledons similar to those of O. compressa, light yellowish-green.

Stem flattened, herbaceous, ultimately woody, reddish-green, glabrous; 1st internode 2–10 mm. long; 2nd shorter.

First leaves ovate-lanceolate, acute, petiolate, glabrous, yellowish-green, with a reddish tinge near the edges, indistinctly one-nerved.

EUPHORBIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 239.

Fruit and Seed.—The ovary is superior, usually three-celled, often two- to four-celled, and sometimes one- or five- to many-celled. The ovules are solitary in each cell or geminate and collateral, pendulous, anatropous, inserted on axile placentas with a ventral raphe and superior micropyle, rarely having a dorsal raphe with the micropyle close to the placenta. The funicle is very frequently developed into a cellular, scale-like, or hooded arillode, sometimes expanded and covering the ovule wholly or in part. The fruit is capsular and falls away at maturity into as many cocci as there are cells, leaving the axis free. Sometimes it is baccate or drupaceous, divided into cells, and indehiscent, very rarely breaking up into two or three pyrenes; or it may by abortion be one-celled and one-seeded. The exocarp is thin or thickened and fleshy; while the endocarp is cartilaginous, crustaceous or hardened. The seeds equal the number of cells or are fewer by abortion; they have a crustaceous, rarely woody or membranous testa. The endosperm is copious and fleshy or rarely cartilaginous or papery. The embryo is central and straight, rarely incurved, and almost equals the endosperm in length, and sometimes in breadth. The cotyledons are broad and foliaceous, rarely fleshy, or narrow and semiterete, very rarely thick and fleshy, or very broad and twisted. The radicle is superior, and short or rarely elongated; and when the cotyledons are very broad and auricled at the base, it is mostly enclosed or surrounded by the auricles.

The species of Euphorbia might also be divided into those having pitted, smooth, or tubercular seeds. The seeds may be divided into three groups.

The seed of E. exigua is obtusely tetragonal and deeply pitted on the two faces obliquely facing the placenta. The cotyledons represent the narrowest type. They are oblong, obtuse, plano-convex, rather narrower and much shorter than the radicle. The seed of E. Lathyris is shortly oblong, slightly compressed, rather truncate at either end, and obliquely so at the hilum where a semi-globular arillode is situated. The cotyledons are rather wider than in the last case and much longer than the radicle. The latter condition is again reversed in E. Peplus in which the radicle is twice as long as the cotyledons. The latter are, however, much wider and oval with their backs to the placenta as in the three previous cases. The seed is oblong, bluntly ridged longitudinally, deeply pitted with circular depressions, and a long furrow on each side of the raphe on the ventral aspect, The broadly oval cotyledons of this species form a connecting link with the next group.

The seed of Euphorbia splendens is globose-oblong, tumid, and covered all over with small warts or elevations. The embryo of this species falls considerably short of the endosperm. The cotyledons are plano-convex, suborbicular, and nearly as wide as the endosperm. The seed of E. platyphylla is subglobose and the embryo very similar to that of the last, but the cotyledons are relatively longer, and somewhat exceed the radicle. The seed of E. Lagascæ is oblong, terete and rather truncate at either end. The cotyledons are broadly oblong, and longer than the radicle. The seed of E. macrorhiza is oblong, compressed, elliptical in transverse section, and truncate at both ends. The cotyledons are broad, short, oblong and about equal to the radicle in length.

The third type is very distinct from either of the foregoing as the cotyledons almost equal the seed, both in length and width, nearly dividing the endosperm into halves as occurs in Sterculia. A good example is that of Jatropha Curcas which has broadly oblong cotyledons deeply auricled at the base and almost completely enclosing the short stout radicle. They are radiately five-nerved from the base, with strong, branching nerves. The endosperm shrinks when dry, and the cotyledons receding with it, a hollow space is left between them. This peculiarity is even more marked in Hevea brasiliensis, where the endosperm is more nearly if not quite divided in half.

The cotyledons are oblong, slightly tapered to the base in conformity with the seed, trinerved and reticulate. The seed is variegated with black blotches and markings on a deep brown or even a pale ashy-grey ground. This is also the case in Ricinus communis which has ovoid-oblong, dorso-ventrally compressed seeds surmounted with a globular arillode. The cotyledons are like those of the two previous species, but fall a little short of the length and breadth of the seed. They are five-nerved in the lower half and closely reticulated upwards. The radicle projects a little beyond them.

Seedlings.—A considerable number of forms of cotyledons are found in the Order, many of them gradually merging one into the other. Several occur in the genus Euphorbia itself, where also the narrowest types are to be met with. The cotyledons of E. Lathyris are long, leafy, linear and show the midrib only. The leaves are opposite and four or more of the primary pairs closely resemble the cotyledons except in being larger, and longer. The cotyledons of E. exigua (fig. 637) are linear or spathulate-linear and closely resemble the first ten leaves except in being longer. The first pair only are opposite. The cotyledons of E. Peplus are oblong-linear and the smallest observed in the Order. The leaves are alternate, except the first pair, and vary between obovate and obovate-elliptic. The bracts are broadly ovate. The cotyledons of Buxus sempervirens (fig. 639) are oblong-linear or spathulate; and the first two pairs of leaves are obovate or elliptic.

The cotyledons of Euphorbia Lagascæ are large, oblong, entire or slightly emarginate, and penninerved with ascending lateral veins. In form and venation they seem to stand alone.

Those of E. Myrsinites are broadly oval, entire and trinerved. The first pair of leaves are similar, but smaller, with more numerous ascending veins. A considerable number of species have broadly oblong-oval cotyledons as typified by Phyllanthus flaccidus (fig. 640). They also in this instance are trinerved at the base, and have above several other, long, incurved nerves. The leaves of the seedling are very similar but larger and alternate. The third to the fifth on the primary axis are reduced to small scales, bearing in their axils leafy branches. The cotyledons of Petalostigma quadrilocularis are larger and taper slightly at the base into hairy petioles, but are otherwise similar to those of the last species. The leaves are considerably smaller, oval and hairy. The cotyledons of Phyllanthus mucronatus are very similar to those of its congener mentioned above. The first four leaves are smaller and obovate. The cotyledons of Euphorbia heterophylla also conform to this type. Those of E. platyphylla slightly depart from it in being wider at the base, oblong-ovate, and alternately penninerved. The two primary leaves are small and obovate. The cotyledons of Mercurialis annua are similar, in being broadly oblong-ovate, but trinerved in the lower half. The first pair of leaves are comparatively large, ovate, serrate and thinly hairy.

The cotyledons of Euphorbia splendens (fig. 638) are more nearly orbicular than those of any other species in the Order coming under my observation. They are also entire or rarely slightly emarginate and obscurely trinerved. The first three leaves are elliptic, finely acuminate and closely penninerved with the nerves incurved. The hypocotyl becomes fleshy and tapshaped while the seedling is yet quite small and has developed but a few leaves. Probably the succulent and leafless species would even be more notable in this respect. During germination the seed is frequently carried up on the cotyledons, and their growth as well as the swelling endosperm cause the crustaceous testa to split along the greater part of its length exposing the endosperm which continues to cover the cotyledons for some time till mostly absorbed. The same or much the same thing occurs in E. Peplus and also in Eschscholtzia amongst the Papaveraceæ.

The cotyledons of Acalypha virginica are orbicular, widely and shallowly emarginate, and trinerved with the primary nerves much branched. The first pair of leaves are opposite, widely and shallowly crenate. The cotyledons of Dalechampia capensis (fig. 645) are also orbicular, sometimes oblong, but they are very subject to malformation, in being undulated, erosely emarginate, often oblique or irregularly cut away at the base, or elsewhere, and variously twisted.

A number of species having more or less succulent or fleshy stems and large seeds are notable for the great size and foliaceous character of their cotyledons. Those of Ricinus communis (fig. 644) are five-nerved, ovate-oblong or oblong, the shape varying even in the same plant. The first two leaves are ovate, palmately seven-nerved and lobed at the base, with a longer terminal lobe and acuminate. Every division is finely serrated. Jatropha podagrica (fig. 643) is notable for its long and succulent hypocotyl. The cotyledons are broadly oblong, trinerved, and slightly auricled at the base. As in other cases the auricles take their origin in the seed, when they occupy the space on each side of the radicle. The first leaf is roundly ovate, peltate, seven-nerved, very blunt and entire. The cotyledons of Jatropha Curcas (fig. 642) are rotund-oblong, entire or emarginate, subauricled at the base, and seven- to nine-nerved. The first leaf is cordate-ovate, and coarsely dentate. The second and third are cordate, acuminate, seven-nerved and incipiently palmately lobed.

A type distinct from any of the above is met with in Jatropha multifida. The cotyledons are large, obovate, fleshy, and remain in the seed which is carried up by the robust and greatly elongated hypocotyl. When dry they are seen to be three- to five-nerved. The first leaf is digitately seven-lobed; the second nine-lobed; and the third and fourth seven-lobed. The divisions of all are pinnatifid, with the ultimate segments subulate, lanceolate or linear. The hypocotyl of Hevea Spruceana (fig. 641) is undeveloped and the cotyledons are subterranean, remaining in the seed till they decay. Both the seeds and the cotyledons are large, and the latter are petiolate as was the case in Jatropha multifida, in order to facilitate their exit and that of the plumule. The primary internode of the stem varies from 12–20 cm. in length; but the second one is only about 3 mm. long. The first two leaves are opposite, and digitately trifoliolate, with oblong-lanceolate, acuminate, entire, and finely penninerved leaflets. The third leaf is alternate, similar in form but smaller.

Euphorbia Lathyris, *L.*

Capsule trilobed, glabrous, glaucous when fresh, three-celled, three-seeded, dehiscing with elasticity and force septicidally and loculicidally; exocarp thick, hard or subwoody, separating from the thin pale-coloured endocarp.

Seed shortly oblong, thick but slightly laterally compressed, arillate, somewhat variegated with brown, sculptured all over, suspended from the axile placenta at the apex of the cell; testa thick and crustaceous; tegmen thin and membranous; hilum and micropyle superior on the pendulous seed and contiguous; raphe ventral; chalaza inferior; arillode whitish, forming a slightly elevated cap or shield on the hilum, crenate at the margin and having a groove on its under side to accommodate the raphe.

Endosperm copious, fleshy, whitish.

Embryo straight, embedded in the endosperm and somewhat shorter than the latter; cotyledons oblong, obtuse, entire, plano-convex, closely applied face to face, lying in the broader way of the seed with their edges to the raphe and axis, much narrower than the endosperm but somewhat broader than the radicle; radicle oblong or cylindrical, obtuse, about equalling the cotyledons in length or shorter, central or lying somewhat obliquely so as to be in the longer axis of the seed, and point to the micropyle at one corner above the cap-like arillode.

Seedling.

Primary root long, stout, tapering, fleshy, subflexuose, with fleshy, flexuose, lateral rootlets.

Hypocotyl erect, terete, fleshy, glabrous, purple and shining, with a few scattered small red protuberances like bilobed glandular processes, about 8·8 cm. long, but very variable according to cultural treatment.

Cotyledons long, foliaceous and slightly smaller than, but precisely similar to the first pair of leaves, sessile, linear, obtuse, one-nerved, glabrous, deep subglaucous-green above, glaucous beneath, subconnate at the base forming a narrow rim around the stem, horizontal, 2·1–5 cm. long.

Stem erect, terete, fleshy, biennial, glabrous, glaucous or suffused with a purplish tint; 1st internode 1·1 cm. long; 2nd and 3rd each 1 cm.; 4th 6 mm.; 5th and 6th 4 mm.

Leaves simple, entire, cauline, opposite, decussate, exstipulate, very shortly petiolate or subsessile, horizontal, deep subglaucous-green above with a white midrib, glaucous beneath, very glabrous, linear-oblong, obtuse, apiculate, with the upper ones wider and longer, flat or the younger ones slightly grooved on the upper side, all similar in shape to the cotyledons and first pair of leaves till near the inflorescence.

Bracts large, ovate and lanceolate, acuminate, subcordate at the base.

Euphorbia exigua, *L.*

Fruit capsular, falling away from the persistent axis into three two-valved cocci, each containing one seed.

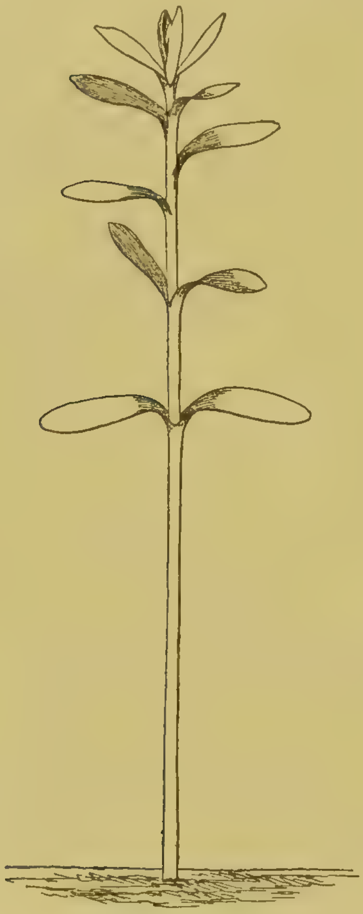

Fig. 637.—*Euphorbia exigua*, × 2.

Seed shortly oblong, small, obtusely tetragonous in transverse section, glaucous or whitish, and deeply pitted all over the two faces nearest the axis; hilum depressed at the apex of the ventral aspect; raphe ventral on the ventral angle; chalaza basal.

Endosperm copious, fleshy or almost farinaceous, white, surrounding the embryo.

Embryo straight, central, nearly as long as the endosperm, but much narrower, colourless; cotyledons oblong, obtuse, entire, plano-convex, much shorter than the radicle; radicle cylindrical, obtuse, but narrowed to the point, much longer than the cotyledons and as broad or slightly broader in the middle, close to the apex of the endosperm, and the hilum of the seed.

Seedling (fig. 637).

Hypocotyl glabrous, bright green, 1·8–2·4 cm. above the soil.

Cotyledons spathulate-linear or strictly linear, obtuse, entire, narrowed to the base and connate, glabrous, glaucous above, bright green beneath and shining.

Stem erect, terete, glabrous, bright green, annual; 1st internode 7·5 mm. long; 2nd 4·5 mm.; 3rd 1·5 mm.; 4th 2 mm.

Leaves alternate (1st and 2nd opposite), entire, sessile, narrowed to the base, with a distinct midrib seen only by transmitted light, glabrous, glaucous above, bright green beneath.

Nos. 1–10. Linear, subacute, narrowed towards the base.

Euphorbia Peplus, *L.*

Capsule as in E. Lathyris, but the pericarp does not split into two distinct layers when mature.

Seeds comparatively small, oblong, capped by a small, white, funicular arillode, somewhat angled longitudinally, deeply pitted with circular depressions and a long oblong one on each side of the raphe on the ventral aspect, grey or glaucous, slightly depressed or truncated at either end; testa subcrustaceous, tegmen thin and membranous; raphe ventral; chalaza inferior, orbicular, and convex or somewhat elevated, and seated in an apical depression; hilum and micropyle superior, with the former lying in a depression formed by the arillode, and oval in outline.

Endosperm copious, fleshy, whitish.

Embryo comparatively large, straight, colourless, central, somewhat shorter than the endosperm; cotyledons oblong, orbicular, entire, plano-convex or nearly flat, lying in the endosperm with their backs to the axis; radicle oblong, much narrower and also longer than the cotyledons, tapering somewhat to an obtuse point, which lies close to the micropyle.

Germination.—The radicle pushes into the soil, fixing the young plant there, and develops root-hairs. The hypocotyl arches, and as it rises up pulls the cotyledons out of the seed, which splits irregularly during the process so as to facilitate their exit. In moist soil and a moderately high temperature, the seeds germinate in nine days.

On the second day after appearing above the soil, the lower part of the hypocotyl is straight and stout; the upper part is still curved downwards and much more slender. The cotyledons immediately after leaving the seed are narrowly oblong, obtuse, entire, glabrous, pale green, and sessile.

Four days after appearing above soil the hypocotyl is nearly straight, and the cotyledons are somewhat larger, oblong, obtuse, entire and very shortly petiolate, with two short lateral nerves at the base and one to two alternate ones upwards.

Seedling.

Primary root normal, annual.

Hypocotyl pale green below, purple upwards, tapering into the root, 1·9 cm. long.

Cotyledons linear-oblong, obtuse, entire, tapering into the petiole which is short and grooved above, 8 mm. long including the petiole.

Stem very similar to that of E. exigua.

Leaves petiolate, subglaucous-green above, glaucous beneath, obovate or varying to obovate-elliptic, obtuse, sometimes though rarely emarginate.

Bracts broadly ovate.

Euphorbia Myrsinites, *L.*

Hypocotyl 2–3 cm. long, light green.

Cotyledons broadly oval, obtuse, entire, shortly petiolate, glabrous, dark green above, lighter beneath, indistinctly trinerved.

Stem erect, terete, herbaceous, light green, glabrous ; 1st internode 3–5 mm. long ; 2nd shorter.

First leaves opposite, sessile, entire, obovate-oblong, obtuse, glabrous, subglaucous-green, indistinctly pinnatinerved.

Euphorbia heterophylla, *L.*

Hypocotyl thicker towards the base, light green stained with red towards the soil, 1·5–2·25 cm. long.

Cotyledons oblong, obtuse, entire, petiolate, glabrous, light green, distinctly pinnatinerved.

The seed splits transversely at the hilum, and the cotyledons have often a considerable difficulty in getting rid of the testa, for which purpose they are often thrown into folds.

The membranous remains of the endosperm frequently stay on the cotyledons long after the testa has been thrown off.

Euphorbia platyphylla, *L.*

Capsule small, roundish, warted, one-seeded.

Seed subrotund or obovate, slightly flattened laterally, 1–1·25 mm. long ; testa crustaceous, light brown, smooth, slightly thickened near the hilum ; hilum rather conspicuous.

Endosperm copious, fleshy.

Embryo straight, embedded in endosperm ; cotyledons oval or suborbicular, obtuse, entire, plano-convex, closely adpressed, lying in the broad way of the seed with their edges to the axis ; radicle obtuse, entire, terete, about equal in length to the cotyledons.

Seedling.

Hypocotyl 3–4·5 cm. long, light green or colourless, with often a slight tinge of red near the base.

Cotyledons ovate-oblong, obtuse, entire, membranous, petiolate, glabrous, light green and, like the leaves, indistinctly pinnatinerved.

Stem erect, terete, glabrous; 1st internode 3–4 mm. long.

Primary leaves entire, alternate, obovate, obtuse, petiolate, glabrous, light green, subglaucous beneath, pinnatinerved.

Euphorbia splendens, *Boj.*

Capsule as in E. Peplus.

Seed shortly oblong, tumid, almost globose, terminating at the upper and basal part in a short, cuspidate, obtuse point which corresponds to the micropyle, covered all over with little obtuse elevations or points, dull grey, suspended from near the apex of the placenta at the inner angle of the cell; testa thick and subcrustaceous; tegmen thin and membranous; hilum and micropyle contiguous, superior; raphe ventral; chalaza inferior.

Endosperm copious, fleshy, whitish.

Embryo comparatively large, falling a little short of the endosperm, in which it is embedded, central, colourless or pale yellow; cotyledons subrotund, obtuse, entire, plano-convex, lying in the endosperm with their backs to the axis or placenta (the diameter of the seed being about equal either way); radicle oblong, obtuse, lying in the endosperm with its point close to the micropyle, equalling or slightly longer, but much narrower than the cotyledons.

Germination.—An early stage shows the testa splitting deeply into halves by the force of growth of the cotyledons, and the swelling endosperm. If only lightly covered the seed is carried up by the germinating embryo. The seedling appears above soil in about thirteen days.

Nine days after germination the testa and endosperm are not yet thrown off, but the as yet very shortly petiolate cotyledons have increased considerably in size, and are now partly uncovered. The glabrous hypocotyl is somewhat fleshy, has increased greatly in length and thickness, and is pale greenish-yellow.

Seedling (fig. 638).

Primary root slender, tapering, often flexuose, with a few lateral rootlets.

Hypocotyl fleshy, erect, clavate, tumid, glabrous, shining, pale green or deep dull red according to exposure.

Cotyledons rotund, entire, petiolate, obscurely trinerved, rarely slightly emarginate, glabrous, deep subglaucous-green above, paler beneath; lamina 8·5 mm. long, 7·5 mm. wide; petiole flattened above, 1·5 mm. long.

Stem shrubby, fleshy, full of latex, branching, much angled by the long, stout, spiny stipules, shortly and densely pubescent when young, afterwards subglabrous, pale green or reddish, ultimately brown or grey; 1st internode 2 mm. long, conspicuously thinner than the hypocotyl; 2nd 1 mm. long; 3rd not developed. Here the first season's growth seems to end.

Leaves simple, entire, cauline, alternate, stipulate, petiolate, pubescent on the midrib beneath, otherwise glabrous, deep subglaucous-green above, paler beneath and glaucous, alternately penninerved, with ascending nerves, curved at their apex and joining, forming a loop, or obscurely anastomosing; petioles short, pubescent, grooved above and rounded on the back; stipules long, spiny, tapering to an acute point, dilated at the base longitudinally, and compressed laterally; the colour of the branch.

Nos. 1–3. Elliptic, acute, or apiculate. Ultimate leaves elliptic, or oblong-elliptic, apiculate.

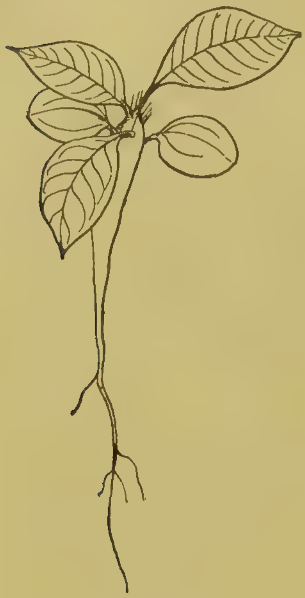

FIG. 638.
Euphorbia splendens.
Nat. size.

Euphorbia macrorhiza, *C. A. Mey.*

Fruit capsular or splitting up into three cocci separating from the persistent axis, triangular or shallowly trisulcate, glabrous, green, reticulate, ultimately ash-coloured, and tipped with the short persistent style and three bifid stigmas; cocci oblong, obtusely tetragonal, disconnected along the interior angle, with a round opening near the apex of that side, through which the funicle or process of the placenta passes, sometimes splitting along the dorsal suture, crustaceous, brittle.

Seed oblong, elliptical in transverse section, hard, smooth, truncate at both ends, deep brown, slightly variegated with a paler colour, crustaceous, capped with a reniform deep yellow or orange, micropylar arillode, the notch of which stands over the minute hilar spot; raphe ventral, extending to the extreme base of the seed, where the chalaza forms a small circular depression.

Endosperm abundant, fleshy, white, surrounding the embryo.

Embryo axile, straight, with a well-developed, pointed radicle; cotyledons flattened, or slightly convex on the back, short, oblong, obtuse, entire, fleshy; radicle stout, pointed, about equalling the cotyledons in length.

Buxus sempervirens, *L.* (fig. 639).

Primary root long, tapering, with a few short, fleshy, adventitious rootlets.

Hypocotyl erect, terete, suffrutescent, glabrous, pale green, 3·3 cm. long, 1 mm. thick.

Cotyledons foliaceous, oblong-linear or spathulate, obtuse, glabrous, deep green, 1·3 cm. long, 3·75 mm. wide, tapering to the base.

Stem suffrutescent, erect, quadrangular from the decurrent lines from the petioles, glabrous, pale green; 1st internode 3 mm. long; 2nd 2·5 mm.

Leaves simple, cauline, opposite, decussate, exstipulate, shortly petiolate, bright green, glabrous, entire, evergreen; petioles slightly grooved above, 1 mm. long.

First and second pairs alike, obovate or subelliptic.

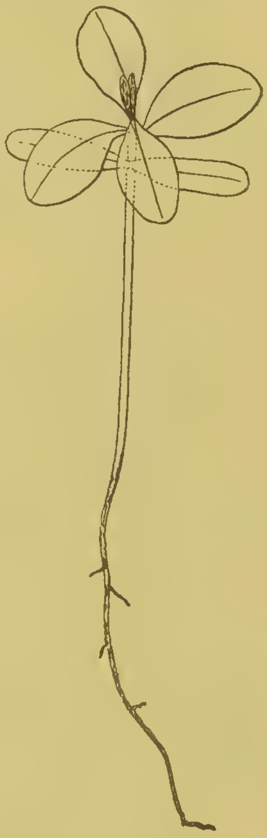

FIG. 639.
Buxus sempervirens.
Nat. size.

Phyllanthus flaccidus, *Thwaites* (fig. 640).

Hypocotyl erect, terete, glabrous, closely mottled with red on a pale green ground, 1·4–1·6 cm. above the ground, more or less covered with minute crystalline papillæ.

Cotyledons oblong-oval, obtuse, entire, alternately incurvinerved, petiolate, glabrous, deep green, firm, horizontal; lamina 9–10·5 mm. long, 4·5–5·5 mm. wide; petiole biconvex or somewhat flattened above, minutely papillose, 1–1·5 mm. long.

Stem erect, terete, slender at this stage, glabrous, minutely papillose, and mottled with red on a pale green ground, ultimately woody; 1st internode 9–11 mm. long; 2nd 4–5 mm.; 3rd 4–5 mm.; 4th 6·5–7·5 mm.

Leaves simple, entire, cauline, alternate, stipulate, petiolate, scattered on the primary stem, and distichous on the lateral branches, alternately incurvinerved and reticulate, glabrous, revolute at the margin, minutely dotted with pale grey on a deep green ground, glaucous beneath; stipules minute, triangular-subulate, acute, pale green, or pinkish, hyaline at the margin; petioles terete, smooth, mottled with red, about 2 mm. long on the primary stem and 1 mm. long on the lateral branches.

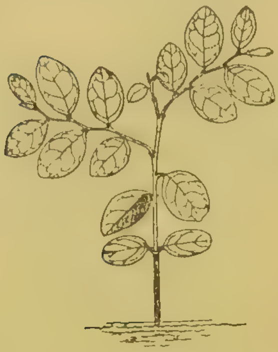

FIG. 640.
Phyllanthus flaccidus.
Half nat. size.

Nos. 1 and 2. Oval or subelliptic, obtuse at both ends.

Nos. 3–5. Reduced to small subulate, acute teeth, similar to the stipules in shape and size or nearly so, bearing in their axils horizontal, leafy branches.

Leaves on the lateral branches similar to the primary ones but smaller, oval or elliptic, obtuse.

Petalostigma quadriloculare, *Müll. Arg.*

Hypocotyl erect, terete, glabrous, light green, 3–5 mm. long.

Cotyledons oval, obtuse, entire, tapering at the base to the petiole, glabrous, dark green, paler beneath, 1·8–2 cm. long including the petiole, which is slightly hairy beneath, 9–11 mm. wide; midrib sending off numerous ascending veinlets as in the leaves.

Stem herbaceous, erect, terete, pubescent, light green; 1st internode 2 cm.; 2nd rather shorter, about 1–1·3 cm. long.

Leaves simple, entire, cauline, alternate, petiolate, with short hairy stipules, pubescent on both surfaces, oval to obovate, obtuse, light green, somewhat reflexed; midrib prominent with numerous ascending veinlets, 1·2–1·3 cm. long, 7–8 mm. wide.

Hevea brasiliensis, *Müll. Arg.*

Ovary of three carpels, three-celled, three-ovuled; ovules pendulous, anatropous; micropyle superior.

Fruit a capsule, large, splitting into two-valved cocci; epicarp rather fleshy; endocarp woody, thick.

Seed pendulous, anatropous, oblong or roundish, large, glabrous, obtusely angled on the ventral aspect in conformity with the inner angle of the fruit, convex on the back, marked with black dots and irregular blotches on a pale or dark brown or ashy ground; hilum oblong or elliptical, nearly superior on the ventral aspect; raphe ventral, lying in a furrow on the central or rather inner angle of the seed, longitudinal, separable from the testa; chalaza at the lower end of the seed; radicle superior, close to the micropyle which occupies the centre of the upper end; testa crustaceous or woody, tough or strong but breaking with a clean transverse fracture; tegmen soft, spongy, pale grey.

Endosperm abundant, fleshy, completely surrounding the embryo, but thinnest at the sides, yellowish or creamy white, 3 mm. wide on the ventral and dorsal faces.

Embryo straight, large, colourless; cotyledons thin, slightly curved at the sides and running through almost the whole length of the seed, closely applied with their backs to the placenta, but so far apart internally (at least when dry) as to leave an ellipsoid hollow, 1 cm. wide and 4–4·5 mm. deep, oblong in outline, with a distinct midrib, trinerved for the lower two-thirds, and then alternately penninerved, obtuse or subtruncate at the apex, cordate at the base.

Hevea Spruceana, *Müll. Arg.* (fig. 641).

Primary root very strong, long, and tapering downwards.

Hypocotyl very short, stout, subterranean, glabrous, pinkish and mottled with yellow.

Cotyledons very large and wide, petiolate, subterranean and remaining in the seed till they decay after absorbing the endosperm; petioles flattened above, convex on the back, dilated and semi-amplexicaul at the base, glabrous, green, of unequal lengths when the position of the seed during germination necessitates it for the convenience of exit of the plumule; the longer 10·5 mm. long; the shorter 7·5 mm.

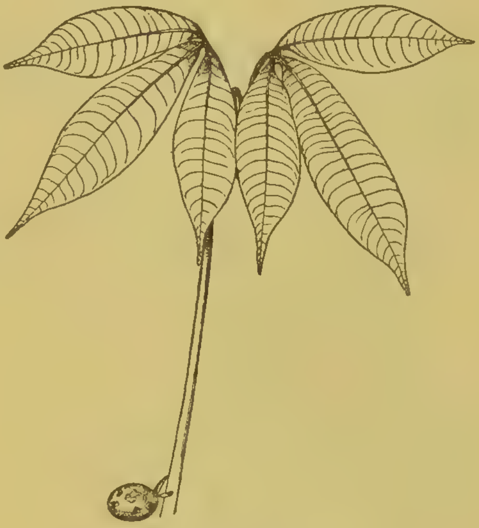

FIG. 641.—*Hevea Spruceana.* One-fourth nat. size.

Stem erect, subcompressed in the young state, glabrous, deep dull green, soon becoming woody; 1st internode 12–20 cm.; 2nd about 3 mm. long.

Leaves compound, cauline, alternate (first two opposite), stipulate, petiolate, with the leaflets subsessile or narrowed to a very short petiolule, alternately incurvinerved, reticulate, entire, glabrous, somewhat shining or glossy, deep olive-green on the upper surface, suffused with a glaucous-purple beneath (at least when young); stipules small, subulate, acute, pale green, interpetiolar in the primary pair; petioles subterete, stout or dilated at the base, and tapering upwards, narrowly channelled on the upper surface, deep dull green, glabrous.

Nos. 1 and 2. Opposite, digitately trifoliolate; leaflets oblong-lanceolate, acuminate, suddenly narrowed at the base into a short petiolule, but not articulated with the rachis, unequal; middle one longest and slightly the widest.

No. 3. Alternate, similar to the first two but apparently on a much smaller scale, and at the end of a very short internode.

Jatropha Curcas, *L.*

Ovary of three carpels, three-celled, three-ovuled; ovules pendulous, anatropous; micropyle superior.

Fruit a capsule, ovoid, blunt at both ends, tipped with the persistent base of the style, with six shallow longitudinal furrows (at least when dry) denoting the dorsal and ventral sutures of the carpels, more or less reticulate, three-celled, three-seeded, falling away in two-valved, one-seeded cocci; endocarp hardened or woody.

Seed large, oblong, blunt at both ends, slightly dorsally compressed, and very obtusely subtrigonous, glabrous, brown, shallowly sculptured all over; testa crustaceous, generally thickest on the ventral aspect, and at each end; tegmen thicker, harder and pale brown; micropyle nearly or quite superior; hilum near the upper end on the ventral aspect and contiguous to the micropyle; raphe ventral; chalaza inferior, large, and thickened internally.

Endosperm copious, fleshy, white, nearly divided longitudinally into halves by the embryo.

Embryo straight, large, nearly equal in length and breadth to the endosperm, colourless; cotyledons large, flat, oblong, obtuse, deeply cordate at the base, palmately five-nerved and somewhat reticulate by branches from the main nerves, adhering to the endosperm which shrinks when dry, leaving a hollow space in the middle; radicle short, stout,

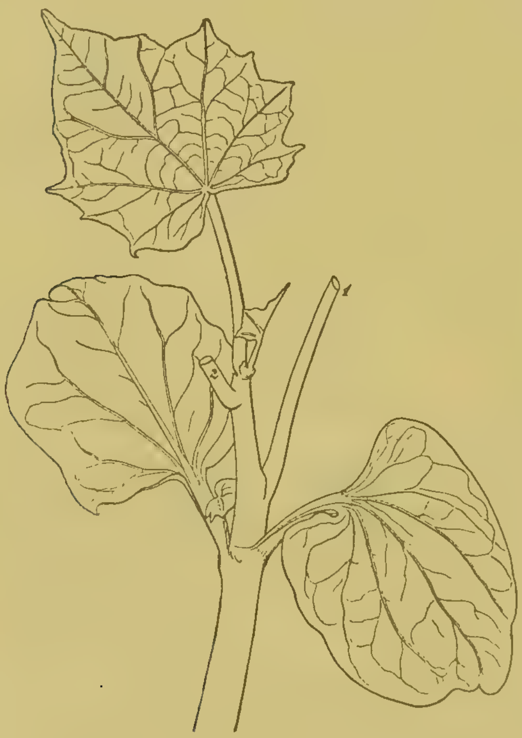

Fig. 642.—*Jatropha Curcas.* Half nat. size.

oblong, obtuse, almost surrounded by the auricles of the cotyledons, imbedded in the endosperm, close to the micropyle.

Seedling (fig. 642).

Hypocotyl erect, stout, succulent, glabrous, smooth, pale green, slightly tapering upwards from 8–9 mm. thick, 3·5 cm. long.

Stem stout, succulent, green, glabrous, shining; 1st internode 1·1 cm. long; 2nd 2·8 cm.; 3rd 6 mm.

Cotyledons roundish-oblong, obtuse, entire, or emarginate, subauricled at the base, palmately seven- to nine-nerved and reticulate, grass green above, paler beneath, glabrous, 6 cm. long and 5 cm. wide, petiolate; petiole 3·2 cm. long, dilating upwards to the lamina, grooved on the upper side, with a bud in one of the axils.

Leaves cauline, alternate, stipulate, petiolate, simple.

No. 1. Cordate-ovate, acuminate, distantly and irregularly dentate-serrate, with the serratures mucronate, palmately nine-nerved, grass green above and glabrous, except in the sinus which is slightly hairy, paler beneath, with very prominent nerves; petiole nearly terete or slightly flattened on the upper side towards the lamina, pale green, glabrous, 8·6 cm. long; stipules small, subulate, acute, almost filamentous.

No. 2. Cordate, acuminate, somewhat angled, but scarcely lobed, coarsely dentate, palmately nine-nerved; petiole terete, otherwise like the first.

No. 3. Similar to, but smaller than the second.

Jatropha podagrica, *Hook.* (fig. 643).

Hypocotyl thickened upwards from 5 mm. at the base to 8 mm. near the apex, 7 cm. long.

Cotyledons broadly oblong, rounded at the apex, obsoletely auricled at the base, palmately trinerved, 3·1 cm. long, 2·2 cm. wide, glabrous and smooth; petiole 1·5 cm. long, semiterete, channelled on the upper side, red.

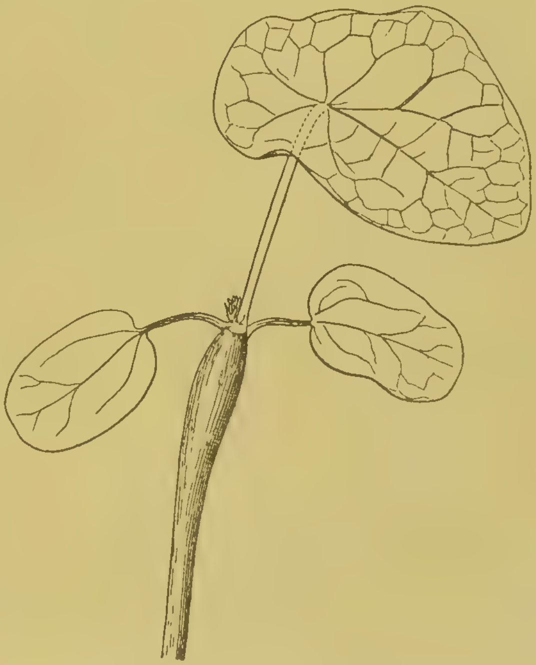

Fig. 643.—*Jatropha podagrica.* Half nat. size.

Leaves cauline, alternate, stipulate, petiolate, simple.

No. 1. Peltate, entire; lamina rotundly ovate in outline, obtuse, entire, radiately seven-nerved and reticulate, pale green above, deeply glaucous or whitish beneath, glabrous; petiole erect, terete, smooth, tapering from 3 mm. at the base to 2 mm. in thickness near the apex, 5 cm. long, pale green suffused with red on the basal half; stipules multifid, tipped with glands.

Jatropha multifida, *L.*

Hypocotyl woody and somewhat fleshy, erect, terete, glabrous, glaucous-green mottled with grey, varying in length from 9·5 cm. to more above the soil, stout, tapering from the base upwards.

Cotyledons large, fleshy, remaining in the seed till it is exhausted, when the whole becomes dry and drops away; petiole about 1·3 cm. long; lamina when removed from the dry seed 1·6 cm. long, 1·15 cm. wide.

Stem succulent, soon becoming woody, tapering upwards and more slender than the hypocotyl, deep green suffused with a glaucous bloom, and mottled with little white protuberances; 1st internode 1 cm. long; 2nd 3 mm.; 3rd 6·5 mm.; 4th undeveloped, bringing the third and fourth leaf opposite, but this is not a constant characteristic.

Leaves simple, digitate, cauline, alternate, stipulate, petiolate, intense green above with white or pale midribs to the primary and secondary segments, glaucous beneath with very prominent midribs, glabrous; petioles terete, glabrous, glaucous, tapering upwards from a stout base; stipules cut into slender, branching, bristle-like processes, pale green or colourless.

No. 1. Digitately seven-lobed; lobes lanceolate in outline, pinnatifid with irregular sized, subulate, acute, aristate segments; basal pair of lobes small with a large segment on the basal, anterior side; middle lobe somewhat deformed.

No. 2. Digitately nine-lobed; lobes lanceolate in outline, deeply and irregularly pinnatifid; basal lobes very small; ultimate segments subulate, attenuate, aristate.

Nos. 3 and 4. Digitately seven-lobed; lobes lanceolate in outline, tapering to both ends or lanceolate-elliptic; basal lobes with a large posterior and basal segment; ultimate segments subulate, attenuate or linear, and mostly aristate.

No. 5. Similar to three and four, but sometimes without large segments at the posterior and basal side of the basal lobes.

Ultimate leaves varying in size, and seven- to ten- or more lobed, with irregularly pinnatifid or pinnatipartite secondary divisions, the longer of which are linear, acute, aristate; the shorter subulate.

Mercurialis annua, *Müll. Arg.*

Hypocotyl erect, quadrangular, glabrous, 4–6 cm. long, light green or colourless.

Cotyledons ovate or subrotund, obtuse, entire, petiolate with rather long petioles, glabrous, light green, trinerved at the base with the midrib dividing into two branches near the centre of the leaf.

Stem erect, quadrangular, herbaceous, glabrous; 1st internode 5–6 mm. long; 2nd considerably shorter.

First leaves simple, cauline, opposite, decussate, petiolate, stipulate, ovate, acute, serrate or crenate, rather hairy, light green, distinctly pinnatinerved; stipules apparently persistent, small; petioles short, channelled on the upper side.

In two out of eight specimens there were three cotyledons, and the first leaves were verticillate in whorls of three.

Acalypha virginica, *Müll. Arg.*

Hypocotyl erect, terete, minutely pubescent, 1·5–3 cm. long, light green or colourless, stained with red near the base.

Cotyledons orbicular, obtuse, slightly emarginate, petiolate, glabrous or with a few minute hairs on the edges and petioles, dark green, trinerved with the principal veins much branched.

Stem with primary internodes but slightly developed.

First leaves simple, cauline, opposite, ovate, obtuse, crenate-serrate, hairy, pinnatinerved, shortly petiolate, stipulate. Subsequent leaves alternate.

Ricinus communis, *L.*

Ovary as in Jatropha.

Fruit dry, trilobed, three-seeded, breaking up into three two-valved cocci.

Seed ovoid-oblong, dorso-ventrally compressed, 1·5–1·65 cm. long, 9–10 mm. wide; testa crustaceous, shining, marked with deep shining brown on a grey ground; raphe ventral; chalaza at the base of the ventral aspect; micropyle superior, forming a large, white, emarginate process, separated from the rest of the seed by a constriction; hilum apical on the ventral aspect, almost concealed by the micropyle.

Endosperm abundant, fleshy or oily, white, surrounding the embryo.

Embryo straight, flat, very large, central, colourless; cotyledons broad, oblong, obtuse, falling a little short of the whole length of the seed, alternately penninerved and reticulate, slightly cordate at the base, adhering to the endosperm and separated from one another; radicle short, stout, oblong, obtuse, extending beyond the cotyledons for about half its length; plumule inconspicuous.

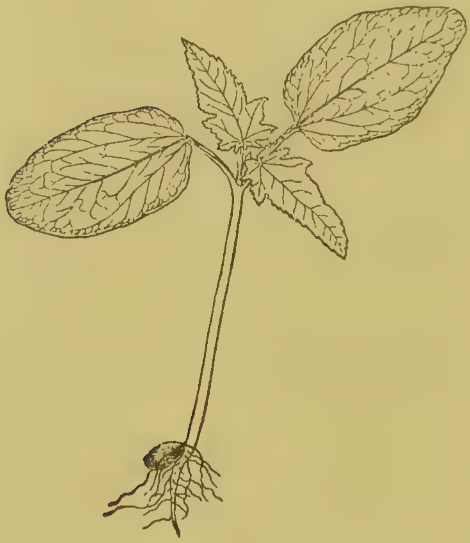

Fig. 644.—*Ricinus communis.* One-fourth nat. size.

Seedling (fig. 644).

Primary root a succulent taproot, not very long, with many thick, colourless, lateral rootlets.

Hypocotyl 10–15 cm. long, 3·5–5 mm. thick, succulent, terete, glabrous, reddish.

Cotyledons with a channelled, glabrous, glandular petiole 3 cm. long, 2·5 mm. broad, 1·5 mm. thick, and an entire lamina, oblong in one and ovate-oblong in the other, rounded or subcordate at the base, very obtuse at the apex, about 8 cm. long, 4–5 cm. wide, palmatinerved at the base, glabrous, thinly succulent, bright green above, paler beneath. The disparity of the cotyledons is probably accidental in the specimen sketched.

Stem very short at first; 1st internode 5 mm. long, half as thick as the hypocotyl, slightly compressed, glabrous, dark green.

Leaves simple, cauline, alternate, with glandular stipules, petiolate, palmately seven- to many-nerved and -lobed especially at the base, with the lobes alternately nerved upwards, reticulated, serrate, glabrous, deep green above, paler beneath.

Nos. 1 and 2. About 6 cm. long at first by 3 cm. wide, palmatilobed at the base; terminal lobe about 4 cm. long by nearly 2 cm. wide, acuminate, subpeltate at first, but splitting at the base after some time so as to render it truly palmati-lobed and -nerved, obtusely serrate and mucronate, glabrous, fleshy but thin, bright green above, paler beneath.

Dalechampia capensis, *Spr. fil.* (fig. 645).

Hypocotyl 2·7 cm. long, 1–1·5 mm. thick, terete, with a short, spreading pubescence.

Cotyledons rotund or rhomboid, oblique, sometimes emarginate, undulated or twisted, and frequently very unequal at the base, palmately trinerved, with sometimes irregular secondary nerves, reticulate, pubescent, and somewhat scabrous above, glabrous below except on the nerves.

Stem terete or slightly angled on two sides, soft, densely covered with long and short spreading pubescence; 1st internode 1·5–3 cm. long; 2nd shorter.

Leaves opposite and alternate, cauline, stipulate, petiolate.

Nos. 1 and 2. Palmately three- to five-nerved, and coarsely serrate-dentate or lobed, with obtuse teeth ending in a minute mucro; lamina more or less triangular with a cordate base, pubescent above and on the nerves beneath, and having two short, cylindrical glands in the basal sinus; petiole terete, channelled above, hirsute, 8 mm. long; stipules contiguous, small, subulate, acute, patent, pubescent.

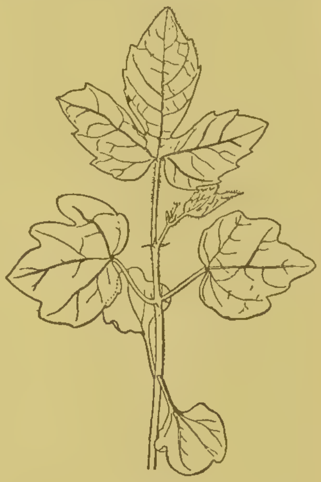

FIG. 645.
Dalechampia capensis.
Half nat. size.

No. 3. Alternate, deeply trilobate, palmately five-nerved, cordate at the base, pubescent above and on the nerves beneath; lateral lobes oblong, oblique, obtuse, mucronate, distantly serrate along the posterior margin, with one to two teeth towards the apex on the anterior margin, irregularly penninerved; terminal lobe subelliptic, obtuse, mucronate, penninerved with two to three serratures on each side.

URTICACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 341.

Fruit and Seed.—The ovary is superior or more or less inferior in a few genera, and always consists of a single carpel, which is one-celled and one-ovuled, or the ovule is rarely accompanied by another, the growth of which however is soon arrested. It is inserted on a basal or nearly basal placenta, is erect or ascending, and orthotropous, very slightly amphitropous; sometimes it is inserted at or near the apex, and is pendulous, anatropous or shortly amphitropous; the micropyle is always superior. The fruit is one-seeded, indehiscent, and generally small, sometimes an achene and dry, fleshy or succulent, free or included in, or adnate to the perianth; sometimes it is a drupe and free, or it consists of numerous carpels, immersed or sunk in a fleshy receptacle or surrounding the thalamus and densely aggregated or united, forming a compound fruit as in the Mulberry. The seed is erect, pendulous or laterally attached and conforms to the cavity of the fruit; the testa is membranous or rarely crustaceous. Endosperm is wanting or forms a thin layer surrounding the embryo, and occupying its sinus in some cases when it is sometimes unilateral. The embryo is straight or curved, and fleshy with a short or minute, superior radicle. Sometimes the cotyledons are variously unequal, folded, or involute, with a superior radicle, or the latter is again curved downwards and incumbent.

Exceptional cases occur where endosperm is copious and fleshy, as in a few species of Trema, in Parasponia, in the tribe Cannabineæ, in Morus, Bosquiea, Sceptrocnide, Parietaria, Urtica dioica, Cypholophus, Thelygonum, and in a few species of other genera.

One of the simplest types of embryo is that occurring in Parietaria officinalis. The seed closely conforms to the ovoid fruit and contains a large quantity of endosperm surrounding the straight embryo, which has oval cotyledons, longer than the radicle. The achene of Urtica dioica (fig. 650) is ovoid and laterally compressed with a smaller quantity of endosperm surrounding the embryo. The cotyledons are orbicular, emarginate owing to a thickening at the chalaza, and longer than the radicle.

A distinct type occurs in Cannabis sativa where the achene is oval and the seed which conforms to it has a small quantity of endosperm between the radicle and the oval, plano-convex, incumbent cotyledons.

A still more complicated type is met with in Celtis occidentalis. The fruit is a somewhat fleshy drupe, one- or sometimes two-seeded, with a bony endocarp. The seed is campylotropous, inserted near the top of the cavity, and when two are present, they are collateral. The endosperm occupies a small space on the ventral aspect of the seed in the folds of the embryo. The latter occupies the dorsal aspect round which it is curved with the radicle incurved and abutting with its tip against the ventral aspect. The cotyledons are broadly oblong, deeply emarginate or bifid at the apex, more or less folded transversely and also deeply infolded at the apex in order to accommodate themselves to the interior of the seed. The apical fission facilitates the folding. They are trinerved in the lower half, and while yet in the seed auricled at the base, but by subsequent growth they become cuneate.

A fourth type is met with in Humulus, which has a spirally coiled embryo. The seed is nearly globular, but slightly elongated at either end, and contains in H. japonicus a small quantity of endosperm alongside the tip of the radicle and a smaller portion in the centre of the coiled embryo. The radicle is terete and considerably elongated. The cotyledons are incumbent, and the inner has one coil more than the outer so that after germination they are of equal length. The outer one makes about two complete coils, and the inner one three coils. The seed of H. Lupulus is exalbuminous; the embryo is coiled in a similar way to the last. When spread out the cotyledons in both cases are linear and plano-convex, or more or less compressed in the middle according to the pressure to which the different portions are subjected.

Seedlings.—About seven different types of cotyledons have come under my observation. The simplest type occurs in Conocephalus niveus (fig. 649) which has very small, orbicular, petiolate cotyledons. The first pair of leaves are very small, ovate and entire; the second pair are roundly ovate and slightly toothed near the top and trinerved; the third pair are cordate-ovate, trinerved and serrate.

The cotyledons of Urtica dioica are somewhat larger than those of the last, rotund, emarginate, pubescent above, trinerved and petiolate. Laportea urens is somewhat similar but has larger cotyledons showing a midrib only. The first leaf is roundly ovate; the second much larger, cordate and inserted almost on the same level; the third is similar to the last but larger. The cotyledons of Girardinia palmata (fig. 651) are comparatively large, obovate-rotund, emarginate, trinerved at the base with a second pair of strong nerves given off from the middle, and all the four laterals are incurved at their apices. The first two leaves are opposite, trinerved, ovate and serrate-dentate. The third and fourth are rotund-ovate; all are covered with coarse stinging hairs projecting at right angles to the surface. The cotyledons of Dorstenia Contrajerva (fig. 647) are rotund, emarginate, rarely oval, subtruncate at the base and trinerved. The primary leaves are cordate, trinerved, distantly dentate, and serrate. They show a tendency to become trifid; and the leaves of the adult are three- to five-lobed. A slight divergence from this type is shown by Ficus bengalensis (fig. 648) which has roundly ovate, emarginate and trinerved cotyledons close to the ground owing to the shortness of the hypocotyl. The first two leaves are opposite, ovate and obscurely crenate, while the third and fourth are alternate, and ovate with a cordate base.

A third type, represented by Maclura aurantiaca, has oblong-oval, entire and somewhat penninerved cotyledons. The two primary leaves are opposite, lanceolate, acuminate, obtuse and penninerved.

A rather distinct type occurs in Celtis occidentalis (fig. 646) which has oblong, deeply emarginate, trinerved cotyledons, cuneate at the base and tapering into a short petiole. The cause of the emargination has been described above as due to folding. In Urtica dioica (fig. 650) it was due to a thickening at the chalaza inside the seed, and is doubtless augmented by unequal growth subsequent to germination. Two of the primary leaves are opposite, ovate, trinerved, serrate and symmetrical at the base. The four succeeding ones are much larger and wider but otherwise similar. The ultimate leaves are unequal at the base, somewhat resembling those of the Elm.

The cotyledons of Cannabis sativa are unequal, obovate-spathulate, sessile and trinerved. The longer cotyledon varies from 1·4–1·6 cm. in length and 5–6 mm. in width, while the shorter one is 1–1·3 cm. long and 5·5–6 mm. wide. Their shape and inequality are due to their being incumbent in the seed. The larger one occupies the periphery of the seed and is curved, while the smaller lying between the long one and the radicle has less space to develop. The first two leaves are opposite as in many previously mentioned species, lanceolate and serrate; but in vigorous seedlings a pair of lobes is developed at the base. The second pair are digitately tripartite with lanceolate, serrate divisions, the middle one of which is much the largest. The third and fourth pairs are digitately four- to five-partite with lanceolate segments; and the ultimate leaves have numerous lanceolate, acuminate, radiating segments. The cotyledons of C. gigantea are downy, but otherwise similar to those of C. sativa. The first two leaves are lanceolate-oblong, while the second pair are deeply tripartite at the base, with the terminal segment much the largest.

The cotyledons of Girardinia heterophylla differ from those of Cannabis in being relatively wider, emarginate, petiolate and alternately penninerved, and from Urtica dioica in shape, venation and their much greater size. The two primordial leaves are opposite, oblong and coarsely serrate. The cotyledons of Forskohlea viridis are relatively narrower than those of the last, and pubescent, but otherwise resemble them. The two first leaves are opposite, lanceolate and distantly serrate.

The seventh type is represented by Humulus japonicus, which has linear, obtuse, or acute cotyledons, slightly connate at the base, and showing a sunk midrib only. They are also finely glandular-pubescent, equal in length, and 2·8–3 cm. long by 2·5–3 mm. wide. The stipules are interpetiolar, and the two from adjoining leaves are connate into one blunt piece. The two first leaves are trifid, and the two following five-lobed and five-nerved.

Celtis occidentalis, *L.*

Pistil syncarpous, superior; ovary one-celled, one- sometimes two-ovuled, surmounted by the deeply bi-fid or -partite style; ovules subapical, pendulous, campylotropous, collateral when two are present; radicle dorsal, superior, close to the apex of the cell, elongated.

Fruit a rather fleshy berry or drupe, ovoid, slightly oblique and tipped with the short, persistent, hardened base of the style, one-celled, one- sometimes two-seeded, deep green when young, becoming pale or yellowish ultimately slightly reddish, glabrous; mesocarp rather fleshy, deep green, ultimately somewhat pulpy; endocarp bony, forming a smooth, hollow sphere, with which the seed conforms.

Seed suspended from one side slightly below the apex, globose with a prominent projecting micropyle close to or at the apex of the carpel, albuminous; testa thin, white when young or immature, marked with a semitransparent spot on the opposite side of the hilum from the radicle; hilum small, orbicular, somewhat prominent.

Endosperm fleshy, white, originally occupying the whole seed, but as the ovary grows becoming more and more pushed towards the hilum of the fruit with a considerable mass in the concave face or hollow formed by the cotyledons.

Embryo fleshy, colourless, straight at first, then becoming concave on the side towards the placenta, and increasing till it attains the length of the fruit; the ends of the cotyledons then curve up the other side of the seed towards the hilum, the apical halves become folded upon each other longitudinally, and the tips sometimes transversely folded; the cotyledons also become emarginate at a very early age, when they are shortly oblong, rounded at the base, subsequently elongating and becoming obovate-oblong, deeply emarginate or bifid, cordate at the base and trinerved, with the midrib forking close to the sinus, one branch entering each lobe of the cotyledon.

Seedling (fig. 646).

Primary root long, tapering, flexuose, and giving off numerous rootlets.

Hypocotyl woody, erect, terete, pubescent, pale green, about 4 cm. long.

Cotyledons oblong, deeply emarginate, cuneate at the base, shortly petiolate, three- or obscurely five-nerved from the base with the midrib forking and one fork going to each of the apical lobes, minutely pubescent, deep green above, paler beneath, 1·7 cm. long including the petiole, 7 mm. wide.

Stem woody, erect, terete, hispid and pale green, ultimately forming a large tree; 1st internode 9–13 mm. long; 2nd 1·4 cm.

Leaves simple, cauline, alternate (first two opposite), stipulate, petiolate, coarsely hairy and pubescent or hispid, ultimately glabrous or nearly so, alternately penninerved and reticulate, plicate in vernation, and covered in the young unfolding condition with clear, crystalline, dot-like glands pellucid in the seedling plant owing to the thinness of the leaves; petiole short, terete, hairy, articulated with the stem; stipules oblong-subulate, hairy, hyaline, caducous, sometimes though rarely half-ovate, subfoliaceous, somewhat persistent in the adult tree.

Nos. 1 and 2. Opposite, ovate, acuminate, coarsely serrate, trinerved in the lower half, with the small stipules parallel and in close contiguity, equal at the base.

Nos. 3 and 4. Similar, but larger.

No. 5. Somewhat unequal at the base, otherwise like the rest, cut away on the posterior basal side.

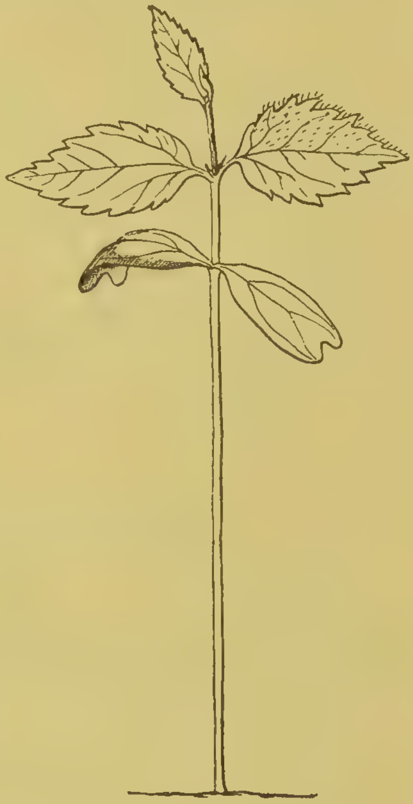

Fig. 646.—*Celtis occidentalis.* Nat. size.

The fruit and seedling of **Celtis australis,** *L.*, are described by Tubeuf (l. c. pp. 54 and 115). They are very similar to those of C. occidentalis, but the cotyledons of C. australis are wider and rhomboidal in shape with a shallower emargination. The first pair of leaves are similarly longer and narrower and acuminate.

Tubeuf also figures and describes (p. 53) fruits of several species of **Ulmus,** and also a seedling typical for the genus (p. 115). He says: 'The cotyledons resemble in shape those of Carpinus Betulus; they are obovate, petiolate, with two basal auricles 1·7 cm. long (not including the petiole) and almost as wide; they are thick, fleshy, green above, whitish beneath, with a venation not at all or with difficulty discernible, and are slightly hairy above with an entire margin. The first leaves are almost sessile, alternate, show a midrib and side nerves, are coarsely hairy like the stem, coarsely serrate, and acute.'

Humulus Lupulus, *L.*

Pistil syncarpous, superior; ovary one-celled, one-ovuled, surmounted by the short style and two linear stigmas; ovule pendulous, campylotropous, attached to the apex of the cell; micropyle superior, close to the hilum.

Fruit an achene, broadly ovoid, compressed antero-posteriorly, in the axil of an accrescent bract which folds over it with one oblique basal side, covered except at the tip with yellow granulose, viscid, highly odorous glands, purplish and finely netted before maturity, afterwards pale brown or grey, sometimes tipped by the two stigmas when nearly mature.

Seed pendulous from the top of the fruit, subobovoid, slightly compressed, with a ridge containing the radicle running along the side opposite to the raphe, pale brown, smooth, somewhat shining, exalbuminous; hilum raised and somewhat prominent on one edge of the seed, a deeper brown than the rest; testa brittle; tegmen greenish and subfleshy, marked by the coils of the embryo and deeply impressed by the radicle.

Embryo in the mature seed spirally twisted and occupying the whole interior, fleshy and colourless; cotyledons incumbent, spirally rolled over one another with their edges towards the edges of the seed and surmounted by the cylindrical, obtuse radicle, linear, obtuse, slightly narrowed to the base, 4·5 mm. long, 1 mm. wide at the apex; radicle 2 mm. long.

Humulus japonicus, *Sieb. et Zucc.*

Achene with thin membranous pericarp, and thicker endocarp, globose.

Seed globose, conforming to the shape of the achene, slightly flattened, 4–4·25 mm. in diameter; testa hard, crustaceous; tegmen almost imperceptible, smooth; hilum inconspicuous.

Endosperm reduced to a fine film surrounding the embryo, greenish.

Embryo spirally coiled, colourless, filling nearly the whole seed; cotyledons as in H. Lupulus; radicle terete, obtuse, incumbent on the back of the cotyledons and about as long.

Seedling.

Primary root tapering gradually downwards, and giving off fibrous lateral rootlets.

Hypocotyl erect, terete, glabrous, reddish, 3–6·25 cm. long, and more or less tinted with red.

Cotyledons linear, entire, obtuse or acute, slightly connate at the base, very shortly and finely pubescent with hairs which become glandular when fully developed, with a distinct midrib sunk on the upper surface, and prominent beneath, 2·8–3 cm. long and 2·5–3 mm. wide.

Stem ultimately twining round some support, with the internodes undeveloped in the seedling stage.

Leaves simple, cauline, opposite, stipulate, petiolate, hairy and glandular; stipules of each pair interpetiolar and connate into one blunt or truncate piece; petiole semiterete, channelled on the upper surface.

First pair tri-fid or -lobed.

Second pair palmately five-nerved and -lobed.

Cannabis sativa, *L.*

Fruit an achene.

Seeds orbicular or oval, 1·5–2 mm. in diameter; testa smooth, greenish-brown; hilum inconspicuous.

Endosperm thin, surrounded by the embryo, fleshy, greyish-white.

Embryo curved or rounded on itself, surrounding the endosperm, colourless; cotyledons oval, obtuse, plano-convex, closely adpressed; radicle terete, obtuse, lying close to the hilum, superior, slightly longer than the cotyledons.

Seedling.

Primary root tapering downwards, flexuose, fibrous.

Hypocotyl erect, terete, pubescent, soon becoming firm and woody, 3–5 cm. long.

Cotyledons unequal, obovate-spathulate, tapering downwards, blunt, sessile and slightly connate at the base, erect for some way above the base and then recurved, pubescent on the upper surface, with a distinct midrib and two lateral nerves arising from the base, which unite with other two nerves arising about the middle of the cotyledon and run to the apex; longer cotyledon 1·4–1·6 cm. long, 5–6 mm. wide; shorter one 1–1·3 cm. long, 5·5–6 mm. wide.

Stem erect, terete, striated, hairy, herbaceous or subwoody; 1st internode 1·8–2·5 cm. long; 2nd longer.

Leaves simple, digitate (first pair merely serrated), cauline, opposite, stipulate, petiolate, distinctly penninerved with ascending nerves, hairy on the upper surface and on the nerves beneath; stipules small, subulate or linear, acute, slightly hairy; petioles semiterete, hairy, channelled above.

First pair lanceolate, obtuse, bluntly serrate, sometimes with two lateral lobes at the base.

Second pair digitately tripartite, with lanceolate obtuse and obtusely serrated segments; terminal segment much the largest.

Third pair digitately four- or five-partite with lanceolate acuminate segments.

Fourth pair digitately five-partite.

Maclura aurantiaca, *Nutt.*

Hypocotyl erect, terete, glabrous, 4–5 cm. long, light green.

Cotyledons rather fleshy, oblong-oval, obtuse, entire, shortly petiolate, glabrous, shiny, dark green above, paler beneath, pinnatinerved like the leaves.[1]

Stem erect, terete, herbaceous, ultimately woody, covered with stout hairs; 1st internode 8–12 mm. long.

First leaves simple, entire, cauline, opposite, lanceolate, acuminate, acute, covered with minute hairs, light green, pinnatinerved; petioles short, channelled, hairy; stipules small, deciduous.

Dorstenia Contrajerva, *L.* (fig. 647).

Hypocotyl erect, terete, pale green, 6–10 mm. long, pubescent.

Cotyledons rotund, rarely oval, emarginate, subtruncate at the base, trinerved, glabrous, variable in size, 5·5–9 mm. long, 7–9·5 mm. wide; petiole slightly channelled above, pubescent, 3–4 mm. long.

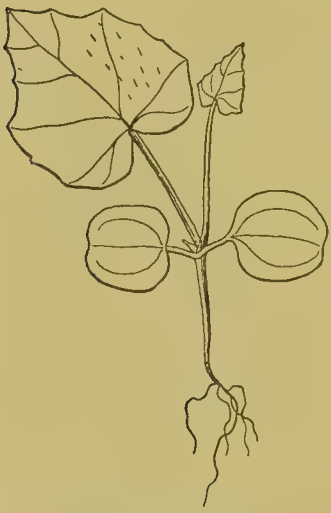

Fig. 647.
Dorstenia Contrajerva.
Nat. size.

Stem herbaceous, stout, fleshy, very short with scarcely developed internodes, forming a perennial rootstock.

Leaves simple, cauline, alternate, stipulate, petiolate, deep green above, thinly hairy, paler beneath and pubescent especially on the nerves, five-nerved on the basal half and alternately nerved upwards; petioles pubescent, terete and channelled towards the apex; stipules subulate, obtuse, green, pubescent.

No. 1. Cordate, subacute, five- to seven-angled, and five-nerved, thinly and obscurely dentate between the angles.

No. 2. More decidedly angled and dentate.

Ultimate leaves deeply trilobed; middle lobe rhomboid or triangular-ovate, acuminate, strongly trinerved and reticulate, with an angle or shallow lobe about the middle on each side, and obscurely dentate along the margins; lateral lobes obliquely ovate, acute, strongly binerved and reticulate, with one of the nerves running into a small lobe on the oblique side.

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[1] Tubeuf, l. c. p. 114, describes the cotyledons as roundly-elliptic, and from 1·7 cm. long.

Ficus bengalensis, *L.* (fig. 648).

Hypocotyl erect, terete, minutely pubescent, or papillose, pale green, 3–4 mm. above the soil.

Cotyledons broadly ovate, obtuse, emarginate, petiolate, glabrous, deep green above, paler beneath, with an indistinct midrib and one to two nerves on each side; lamina 3·5–4 mm. long, 2·75–3 mm. wide; petiole flattened above, dilated and slightly connate at the base, 1–1·25 mm. long.

Stem erect, terete, minutely pubescent or papillose, pale green, ultimately woody; 1st internode ·5–2·5 mm. long; 2nd ·5–1·5 mm.

Leaves simple, cauline, alternate (first two opposite), stipulate, petiolate, alternately or sometimes, especially at the base, oppositely incurvinerved, glabrous, somewhat shining on both surfaces, deep green above, paler beneath, evergreen, ultimately coriaceous; stipules erect, small, subulate, acute, pale green; petioles semiterete, channelled above, slightly tapering upwards, glabrous or minutely papillose on the upper edges, at least when young.

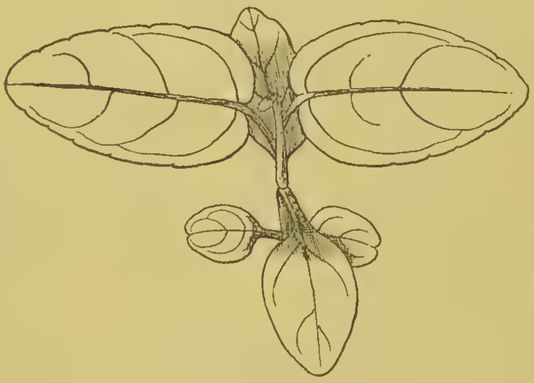

FIG. 648.—*Ficus bengalensis*, × 2.

Nos. 1 and 2. Opposite, ovate, obtuse, slightly cuneate at the base, obsoletely crenate or almost entire.

Nos. 3 and 4. Alternate, ovate, obtuse, shallowly cordate at the base, very shallowly crenate.

Tubeuf (l. c. p. 53) describes fruit and seed of **Morus alba** (the Mulberry), and (p. 114) also figures and describes the seedling. The embryo lies curved in the albuminous seed. The cotyledons remain in the testa till they have absorbed the endosperm; they are 8–9 mm. long, dark green above, lighter beneath, taper gradually into the short petiole, and have a faint venation consisting of a midrib with a few side nerves. The first leaves are irregularly dentate, have a midrib with lateral nerves, and including the petiole are slightly hairy.

Conocephalus niveus, *Wight* (fig. 649).

Hypocotyl 1 cm. long, 1·5 mm. thick, terete, herbaceous, pale green, pubescent.

Cotyledons petiolate, pubescent; lamina rotund, 2 mm. long, thin, or almost membranous; petiole 1·5 mm. long, slender.

Stem erect, terete, herbaceous, pubescent and hairy, pale green, about 2 mm. thick; 1st internode 4 mm. long; 2nd 9 mm.; 3rd 1·1 cm.

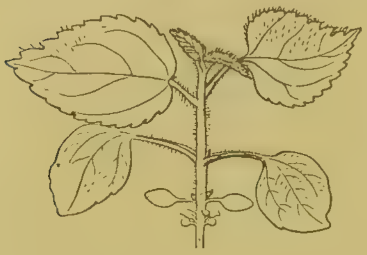

FIG. 649.—*Conocephalus niveus.* Half nat. size.

Leaves cauline, opposite, decussate, exstipulate, petiolate, pubescent, and coarsely hairy on the younger leaves; less hairy on older ones.

First pair small, ovate, obtuse, entire; petiole slender, semiterete, 3–4 mm. long.

Second pair much larger; rotund-ovate, obtuse, palmately trinerved, obsoletely and distantly serrate; petiole semiterete, channelled above, closely pubescent, and sparsely hairy.

Third pair scarcely opposite, cordate-ovate, acute, coarsely serrate; nerves ascending and incurved; serratures subtriangular.

Urtica dioica, *L.* (fig. 650).

Pistil apocarpous, superior; ovary of one carpel, one-celled, one-ovuled; ovule basal, erect, orthotropous; micropyle superior.

Fruit an achene, ovate, compressed, glabrous, included in the somewhat accrescent perianth, tipped by the persistent base of the style, subancipitous, straw-coloured; pericarp subcrustaceous.

Seed ovate, compressed, closely conforming to the interior of the achene; testa thin, membranous, closely applied to the interior of the pericarp; micropyle apical, and superior; hilum and chalaza basal, the latter dark-coloured and rather prominent, causing an emargination in the endosperm and cotyledons.

Endosperm forming a thin layer round the embryo, subfarinaceous, white.

Embryo central, straight, large, nearly equalling the length and breadth of the seed, colourless; cotyledons rotund, obtuse or minutely emarginate with a small rounded or obtuse tooth in the notch, subtruncate at the base; radicle oblong, terete, obtuse, pointing to the micropyle close to the apex of the seed, somewhat shorter than the cotyledons.

Seedling.

Primary root slender, tapering, with fibrous lateral rootlets.

Hypocotyl succulent, terminating abruptly at the lower extremity, slightly pubescent, pale green, mottled with red, 1·1 cm. long.

Cotyledons rotund, emarginate, pubescent on the upper surface, glabrous beneath; lamina 4 mm. long, 4·5 mm. wide; petiole long slender, channelled above, slightly pubescent, pale green or transparent, 4 mm. long.

Stem herbaceous, erect, ridged and furrowed, pubescent with short deflexed and bulbous-rooted, stinging hairs, pale green or stained purple on the ridges; 1st and 2nd internodes each 1·5 cm. long.

Leaves simple, cauline, opposite, decussate, stipulate, petiolate, pubescent on both surfaces, and, like the stem, more or less abundantly furnished with bulbous-rooted stinging hairs on both surfaces, five-nerved at the base, and alternately penninerved upwards; nerves incurving, reticulate; petioles subterete, narrowly channelled above, and shallowly ridged and furrowed on the back, pubescent, and usually bristly with stinging hairs; stipules small, subulate, acute, subciliate in the seedling plant, ovate-oblong, obtuse, trinerved, ciliate, and pubescent in the adult.

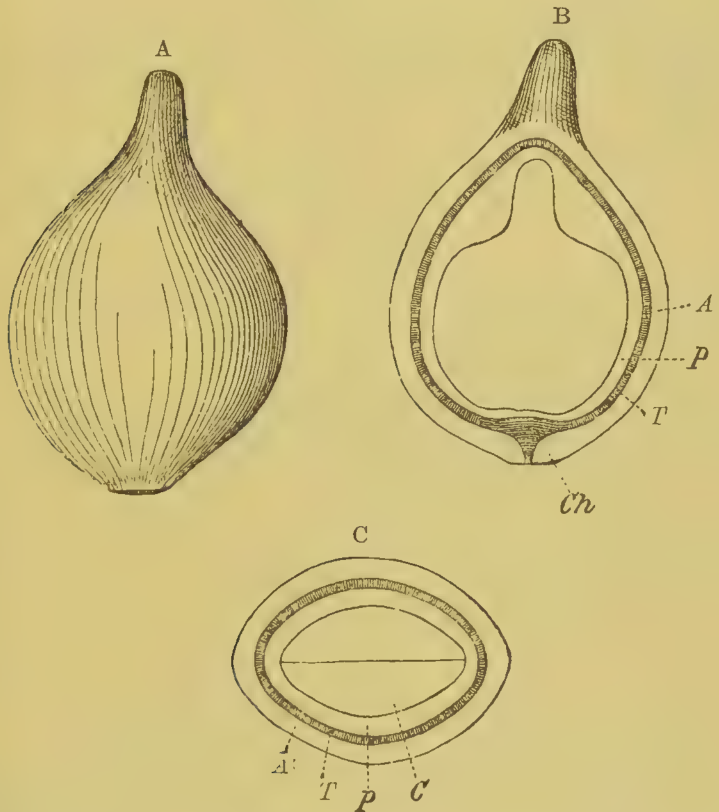

FIG. 650.—*Urtica dioica*. A, achene, × 30. B, longitudinal section of achene, × 30: *Ch*, chalaza; *T*, testa; *P*, endosperm; *A*, pericarp. C, transverse section of achene, × 30: *A*, pericarp; *T*, testa; *P*, endosperm; *C*, cotyledon.

First pair small, broadly ovate, obtuse, coarsely serrate, trinerved at the base.

Second pair triangular, obtuse, coarsely serrate, five-nerved at the base.

Third pair cordate, obtuse or subacute, five-nerved at the base, coarsely and obtusely serrate; serratures frequently aristate.

Ultimate leaves cordate, acuminate, acute, with acute or subacute serratures; nerves sunk above, prominent beneath.

Girardinia palmata, *Wedd.* (fig. 651).

Hypocotyl erect, terete, minutely and finely pubescent, pale green, 2–3 cm. above the soil.

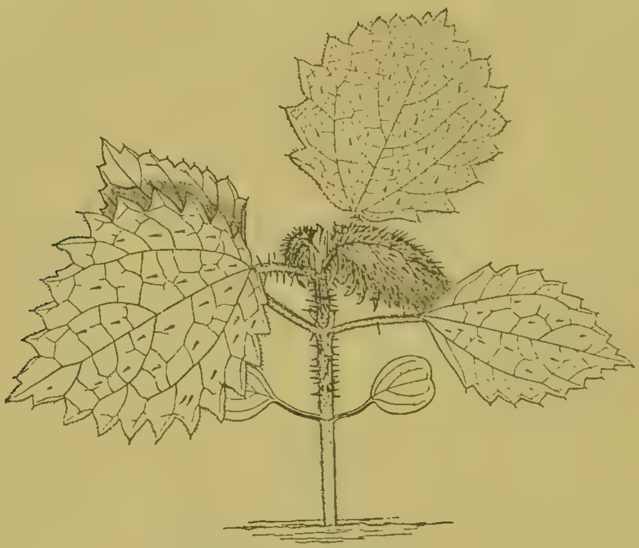

Fig. 651.—*Girardinia palmata.* Half nat. size.

Cotyledons rather large, obovate-rotund, emarginate, suddenly tapered into the petiole, trinerved, the lower nerves springing from near the base of the lamina, describing an intramarginal curve, and uniting with the next pair, which in turn meet the midrib below the thickened apex close to the apical notch, glabrous, light green; lamina about 1·3 cm. long, 1·2 cm. wide; petiole slender, semiterete, channelled above, minutely pubescent, 8–10 mm. long.

Stem erect, terete, finely pubescent and furnished with coarse, stinging barbs, or hairs; 1st internode 1·9 cm. long; 2nd undeveloped; 3rd 7·5 mm.; 4th 3 mm.

Leaves simple, coarsely toothed and lobed, cauline, alternate (first two opposite), stipulate, petiolate, trinerved from the base, alternately nerved upwards and reticulate, hairy on both surfaces, and furnished with coarse, bulbous-rooted, stinging hairs projecting at right angles from both surfaces of the leaf; petiole semiterete, shallowly channelled above, pubescent with rather fine, ascending or subadpressed hairs, and frequently well provided with large stinging hairs; stipules intrapetiolar, erect, connate into one acute binerved piece, pale-coloured or almost scarious.

Nos. 1 and 2. Opposite, ovate, acute, trinerved, obtusely serrate-dentate, the teeth tipped with a hair; the strong lateral nerves become incurved upwards, and run obliquely into the teeth, giving off lateral branches into adjoining teeth.

Nos. 3 and 4. Alternate, rotund-ovate, cordate at the base, more deeply and coarsely serrate-dentate than the first two, with a similar venation.

Nos. 5 and 6. Deeply incised or lobulate with the lower lobes again toothed. Venation as in those above.

Girardinia heterophylla, *Dcne.*

Hypocotyl erect, striated, 1–1·5 cm. long, glabrous, light green or colourless.

Cotyledons obovate or subrotund, obtuse, emarginate, subfleshy, petiolate, glabrous, green, pinnatinerved like the leaves.

Stem short, erect, quadrangular, hairy; 1st internode 3–5 mm. long.

First leaves simple, cauline, opposite, decussate, oblong, coarsely serrate, subacute, hairy, and also covered with stings, green, pinnatinerved; petioles short, channelled above; stipules small, deciduous.

Parietaria officinalis, *L.*

Pistil syncarpous, superior; ovary of two carpels, one-ovuled; ovule erect, orthotropous; micropyle superior.

Fruit an achene; pericarp hard, crustaceous, shining; seed conforming in shape to the achene, oval, oblong or obovate; testa smooth, membranous; hilum inconspicuous.

Endosperm comparatively copious, fleshy, surrounding the embryo, greyish-white or almost colourless.

Embryo straight, in the centre of the endosperm; cotyledons broadly oblong, or oval, obtuse, entire, plano-convex, lying with their apices to the receptacle; radicle terete, obtuse, about the same length as the cotyledons.

Forskohlea viridis, *Ehrenb.*

Hypocotyl erect, terete, finely pubescent, 1–1·5 cm. long, light green, faintly tinged with red.

Cotyledons oblong-obovate, minutely emarginate, finely pubescent, light green with reddish petioles, pinnatinerved like the leaves.

Stem erect, terete, herbaceous, finely pubescent; 1st internode 3–7 mm. long.

First leaves simple, cauline, opposite, oblong, obtuse, dentate-serrate, petiolate, stipulate, finely pubescent, light green, pinnatinerved.

PLATANACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 396.

Fruit and Seed.—The ovary is linear, one-celled and one-ovuled with the wall greatly thickened on one side. The ovule is solitary, rarely are there two, one of which becomes aborted, pendulous from the apex of the cavity and orthotropous. This arrangement is very rare, as in dicotyledonous plants the ovule when single and orthotropous is in almost all other cases erect, the result of which seems to be to facilitate the easy access of the pollen-tube to the micropyle. The achenes are linear, surrounded at the base by long brown hairs, greatly thickened or clubbed in the upper part, and surmounted obliquely or on one side by the persistent remains of the style. The seed is solitary, pendulous, and linear with a membranous testa. Endosperm is usually present in small quantity surrounding the embryo, but is said to be sometimes absent. The embryo completely fills the remainder of the cavity, and is straight and linear. The cotyledons are plano-convex, very little wider than the inferior radicle and about equal to it in length or slightly longer. They generally lie in the broader plane of the seed with their edges towards the thickened portion, but are sometimes oblique to it.

The Order is represented by the single genus Platanus, consisting of five to six species. The above characters are well seen in longitudinal and transverse sections of the achene of a species of Platanus, probably P. orientalis (fig. 652).

Seedlings.—The seedling of P. orientalis (fig. 653) is comparatively small in conformity with the seed, but rapidly gains strength as growth proceeds. The slender hypocotyl rises about 1·1 cm. above the soil, and is surmounted by narrowly spathulate, obtuse, one-nerved, sessile cotyledons tapering to a very narrow base. They are 8·5 mm. long and about 2·5 mm. wide at the apex. The first leaf is small, glandular-pubescent, and resembles a petiole. The second one is spathulate-cuneate, incipiently trifid or bluntly tridentate at the apex, and alternately penninerved, with two of the stronger nerves running into the teeth, thus foreshadowing lobing. The third leaf is much larger, but otherwise similar. The ultimate leaf is palmately five-nerved and -lobed; but the nerves for the lower pair of lobes often arise from the middle pair near the base.

Platanus orientalis, *L.* (fig. 652).

Pistil superior; ovary of one perfect carpel, one-celled, one- to two-ovuled; ovule pendulous from the top of the cell, orthotropous; radicle inferior.

Fruit an achene, one-celled and one-seeded, thickened and woody along one side, surrounded at the base by numerous, long, pale brownish, erect hairs, topped by a large woody process or callus which is surmounted by the persistent remains of the style.

Seed linear-clavate, suspended with the thick end uppermost, flattened on the side next the thickened portion of the pericarp; testa prolonged at the apex into an acute colourless point, and at the base into a colourless, blunt point, otherwise brown, easily broken up longitudinally into fibrous shreds; micropyle at the lower blunt end.

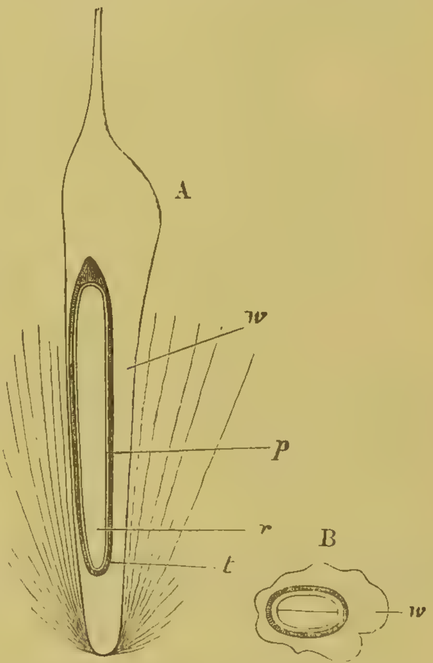

FIG. 652.—*Platanus orientalis.* A, longitudinal section of fruit, × 6: *w*, woody part; *p*, endosperm; *r*, radicle; *t*, testa. B, transverse section of fruit: *w*, woody part, × 12.

Endosperm forming a thin layer surrounding the embryo on all sides, whitish internally, brown externally.

Embryo straight, in the centre of the endosperm, colourless, about 5·25 mm. long; cotyledons linear, suddenly pointed, subacute, a little longer and slightly broader than the radicle; radicle cylindrical, obtuse, at the opposite end of the seed from the hilum.

Seedling (fig. 653).

Hypocotyl erect, terete, slender, pale green, glabrous, about 1·1 cm. above the soil.

Cotyledons narrowly spathulate, obtuse, entire, tapered to the base, glabrous, opaque-green, distinctly one-nerved, 8·5 mm. long, 2·5 mm. at the widest.

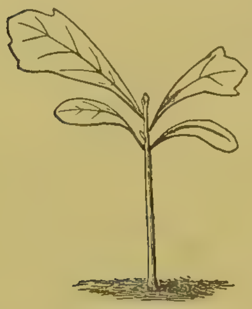

Fig. 653.
Platanus orientalis.
Nat. size.

Stem woody, erect, terete, glabrous or slightly glandular below the leaves; 1st internode about ·5 mm. long; 2nd and 3rd each about 1 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, glandular-pubescent at the margins and midrib (in young specimens); petioles channelled above; stipules small in the seedling, surrounding the base of the petiole, to which they are adnate, but in the adult stage of the tree they are of considerable size, cup-like and deciduous.

No. 1. Reduced to a short petiole, and glandular-pubescent.

No. 2. Spathulate-cuneate, bluntly tridentate at the upper end, alternately penninerved, with the nerves ascending and the larger ones running directly into the teeth.

No. 3. Similar but larger.

In **Platanus occidentalis**, *L.*, the cotyledons are narrow, lanceolate with a prominent midrib, 1·2 cm. long, 2 mm. wide, acute, sessile, and shining green above.[1]

The first leaves are alternate, entire, elongated-oval, serrate with shortly pointed teeth, with midrib and lateral nerves.

JUGLANDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 397.

Fruit and Seed.—The ovary is inferior and one-celled with a solitary, basal, erect, orthotropous ovule. The fruit is drupaceous or rarely nut-like and dry, sometimes with the bract and bracteoles enlarged at its base, or partly or wholly adnate to its sides or even carried to the top forming an involucre; in other cases these organs remain unchanged and fall away. The exocarp is fleshy or succulent, generally falling away when mature, leaving the bony endocarp which is variously excavated into two or four cavities internally. The seed is two- to four-lobed at the base and lies astride the placenta with its lobes passing down into the cavities of the endocarp. Endosperm is wanting, and the embryo conforms to the interior of the seed. The cotyledons are fleshy and crumpled, or sometimes foliaceous and much folded and twisted, and the radicle is superior.

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[1] *Vide* Tubeuf, l. c., p. 116, fig. 153.

I have already described and figured the seed and seedling of Peterocarya caucasica,[1] which are very peculiar. I have to thank Mr. Lynch for his kindness in keeping me supplied with specimens of the fruit in its various stages from the tree in the Cambridge Botanic Gardens. The seed[2] is shaped somewhat like an anvil, with four short, wide legs; and the seedling is remarkable in having the cotyledons bifid, each division being again bilobed.

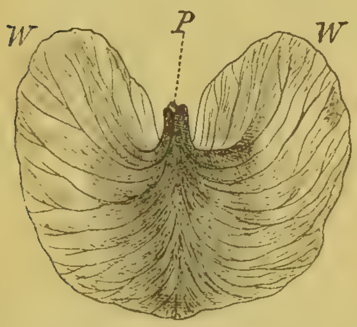

FIG. 654.—Fruit of *Pterocarya*, × 2: *P*, perianth; *W*, *W*, wings.

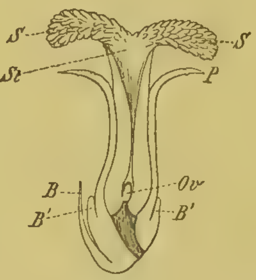

FIG. 655.—Longitudinal section through the flower of *Pterocarya caucasica*, × 6: *B*, bract; *B'*, *B'*, bracteoles; *Ov*, ovule; *P*, perianth; *St*, style; *S*, *S*, stigmas. May 23.

Pterocarya caucasica flowers with us early in May. The pistil is syncarpous and inferior; the ovary of two carpels, one-celled, one-ovuled; the ovule basal, erect, and orthotropous.

Fig. 655 is a section through the young flower at the end of May, showing a bract *B* at the base, two bracteoles *B' B'* at the sides, the ovule *Ov*, perianth *P*, and *SS* the two large, spreading, papillose stigmas. The cavity of the ovary is small and nearly filled by the ovule.

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[1] *Journ. Linn. Soc. Bot.* vols. xxii. and xxviii.

[2] *Ibid.* vol. xxii. p. 386, fig. 118.

By about the middle of June the young fruit has grown considerably in thickness, though not much in length. The ovary and ovule are longer, and at the base of the former the tissue has in two places (fig. 656, *Co*, *Co*) become almost colourless from the removal of the protoplasm.

By the end of June the fruit has still further increased in length as well as in breadth. The growth in length has especially taken place between the base and the uppermost point of attachment of the bracteoles, which therefore seem to have been carried up. The bracteoles have also increased in size, while the perianth remains unaltered. The two masses of colourless tissue as seen in longitudinal section at the base of the ovary are still solid or unbroken.

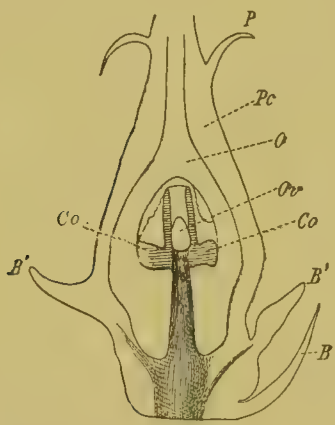

FIG. 656.—*Pterocarya caucasica.* Longitudinal section of fruit, × 6. June 25. *Co*, *Co*, two places where the tissue has become colourless. (Other letters as in fig. 655.)

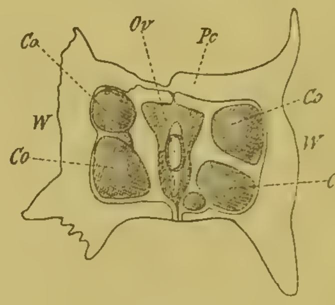

FIG. 657.—*Pterocarya caucasica.* Transverse section of fruit, × 3: *W*, *W*, wings; *Pc*, pericarp; *Co*, *Co*, *Co*, *Co*, four spaces of altered tissue; *Ov*, ovule. (Other letters as in fig. 655.)

The fruit continues to grow rapidly, especially at the base, so that by the end of July the posterior half of the bracteoles seems to be carried still further up, distinctly more so than the anterior. The neck of the fruit, on the contrary, has increased considerably in thickness, but scarcely at all in length. Fig. 657 represents a transverse section, and on each side of the ovule (*Co*, *Co*, *Co*, *Co*) are the four approximately circular patches of colourless tissue, which in a longitudinal section appear more elongated. In them the tissue is commencing to disintegrate, while round them, on the contrary, it is becoming distinctly sclerenchymatous. From the development of the lower part of the fruit, especially on the posterior side, the posterior portion of each bracteole appears to be nearly on the summit of the fruit, the anterior portion being rather lower down.

Fig. 658 is a longitudinal section taken on August 8. It passes through two of the masses of loose tissue mentioned above, which now form cavities; while, on the other hand, the surrounding tissues have become much denser, leaving, however, oval spaces of cortical tissue shown in section at *Co′*, *Co′*.

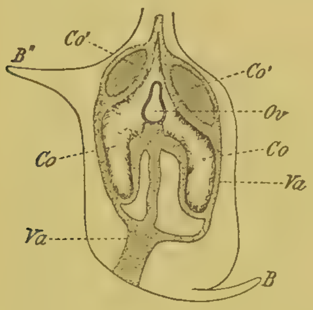

Fig. 658.—*Pterocarya caucasica*, × 3: *Va*, *Va*, vascular tissue; *Co′*, *Co′*, masses of solid cortical tissue; *Co*, *Co*, cavities.

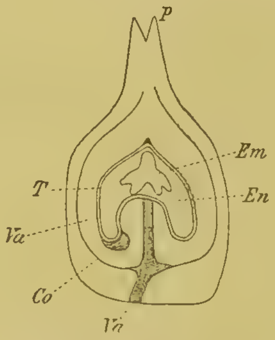

Fig. 659.—*Pterocarya caucasica*. Longitudinal section of more advanced fruit, × 3. Sept. 1. *T*, testa; *En*, endosperm; *Em*, embryo; *P*, perianth; *Va*, vascular tissue; *Co*, small cavity not yet filled by the seed.

The ovary has not materially altered, and the ovule is still very small.

A few days later, however, the ovule has grown considerably and nearly fills the cavities. Fig. 659 shows a longitudinal section taken on September 1. *T* is the testa, showing that the seed has now assumed its four-lobed form, though it has not yet quite filled the cavities in the fruit. The greater part, however, is occupied by endosperm, the embryo (*Em*) being still comparatively small.

Fig. 660 represents a transverse section near the base of the fruit, taken on September 21, when the fruit and embryo had attained nearly their full size, but had not yet reached maturity. Neither the placenta nor the original and true cavity of the ovary are shown in this section, because they were situated at a higher level. The ovule from the first was basal, and the seed, even at maturity, may be looked upon as lying astride the basal placenta, with its four lobes projecting into as many cavities excavated from the originally solid base of the fruit. The testa is shown at T, lining the interior of the cavities and enclosing the variously folded lobes of the cotyledons (C, C, C, C). The walls surrounding the cavities are thick and sclerenchymatous, with exception of the thin outer rind and its appendages, the bracteoles or wings, shown at B', B'. The cotyledons of the embryo diverge, one to each side of the fruit, and their lobes pass in pairs into each of its four cavities. As growth proceeds and the short lobes become too wide for the cavities, they become conduplicate in order to accommodate themselves to the restricted space and at the same time to fill it. The secondary fission seems intended to facilitate folding, and was probably originally brought about by excessive plication. If the two lobes had been in one piece, the latter would have had to be twice conduplicate longitudinally, which would have been difficult to accomplish. The folding is not always on the same plan, as may be seen by reference to the figure.

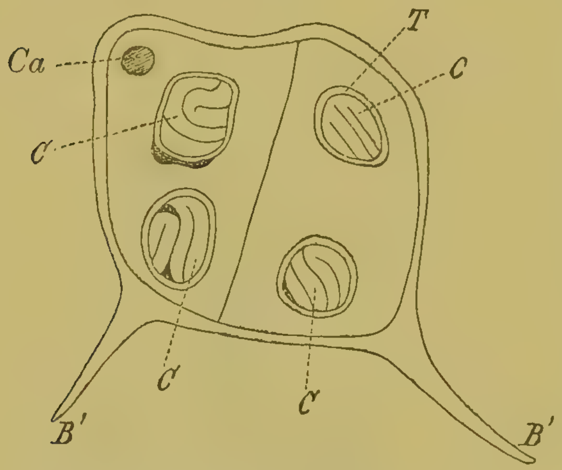

FIG. 660.—*Pterocarya caucasica.* Transverse section through a more advanced fruit near the base, × 6. (Sept. 21.) T, testa; C, C, C, C, folds of cotyledons; B', B', bracteoles or wings; Ca, small mass of cortical tissue.

The Walnut (Juglans).—The fruit of the Walnut differs from that of Pterocarya in several remarkable particulars, and while the cotyledons of Pterocarya are leaf-like and aerial in germination, those of the Walnut never emerge from the seed.

Chabræus long ago remarked on the wonderful richness of nature as displayed in the Walnut, 'præsertim miranda figuræ luxuria naturam in hoc fructu lusisse certum est.' The Walnut, from its fancied resemblance to a head, the outer woody covering being compared to the skull, and the folds of the cotyledons to the convolutions of the brain, was formerly supposed to be especially efficacious in brain-disease.

In the Walnut (Juglans regia) the ovary is one-celled or imperfectly four-celled, one-ovuled; the ovule is erect and orthotropous, with the micropyle superior. The fruit is drupaceous, oblong-globose, crowned with a small point consisting of a three- to five-toothed involucre formed by the union of the bract and bracteoles, by the remains of the four-toothed perianth and the remains of the style; exocarp or rind smooth, and beset with submerged glandular dots bursting irregularly when mature, subfleshy; endocarp hard, bony, or brittle, corrugated, with a spongy lining or inner coat which forms large irregular corrugations internally, and is apparently excavated into four large cavities at the base; the excavations are continued to the top of the main cavity of the ovary, hollowing out the sides of the endocarp so as to furnish a larger amount of space for the seed than is originally provided for it. In Bentham and Hooker's 'Genera Plantarum' the base of the endocarp is said to be intruded, imperfectly dividing the fruit into two or four cells. The endocarp further consists of two valves or halves, which, however, cannot be separated without force.

The seed is large, strongly and irregularly corrugated, seated on the central and originally basal placenta, which in the mature fruit is about one-third above the base of the cavity of the endocarp, deeply four-lobed at the base and filling the four cavities; the testa is thin, closely applied to the corrugations of the endocarp externally before the seed becomes dried up, and internally to the lobes of the embryo, pale brown.

In the young state the endosperm fills the interior of the seed with a clear jelly-like mass, in the apex of which is the small embryo, with the radicle upwards. Gradually, however, the cotyledons grow and eventually absorb the whole of the endosperm, thus filling the whole of the interior of the seed, except, of course, the small portion occupied by the plumule and radicle.

We have seen that in the fruit of Pterocarya four hollow spaces gradually form themselves in the originally solid fruit, and that into these spaces the seed sends four prolongations, into which again the cotyledons subsequently grow. Now in the Walnut a very similar process takes place, only the hollow spaces are much larger and confluent with the ovarian cavity, so that instead of a solid wall with hollow spaces occupied by the seed, it gives the impression as if the seed were thrown into folds occupied by the wall of the fruit. To occupy these spaces fully, the cotyledons themselves were thrown into folds as we now see them. The fruit of Pterocarya is much smaller than that of the Walnut, the ancestors of which doubtless had a smaller fruit. As it increased, the cotyledons became fleshier and fleshier, and found it more and more difficult to make their exit from the seed, until at last they have given up any attempt to do so. Hence the curious folds, with which we are so familiar, are the efforts made by the original leafy cotyledons to occupy the interior of the nut.

Comparison of the Fruits of Pterocarya and Juglans.—Thus, then, while essentially similar, the fruits of Pterocarya and of the Walnut offer several remarkable differences. They resemble in some respects the relations between the fruits of the Hornbeam and of the Beech. The fruit of Pterocarya, like that of the Hornbeam, is winged, which is not the case with the Walnut or the Beech; it is in the two former smaller, and a great deal harder than in the two latter. Again, the cotyledons of Pterocarya are aerial, while those of Juglans no longer perform the functions of leaves and never quit the seed.

In the Walnut, as in some other trees, it is an advantage that the seeds should be large rather than numerous. In this way they are able to contain a supply of nutriment, which suffices rapidly to carry the young plant above the grasses and other low herbage. These seeds form the food of squirrels and other animals, which accordingly serve to disperse them, and thus perhaps they are enabled to dispense with any other means of transport. Moreover, for such large fruits wings would perhaps be scarcely adequate.

In Pterocarya, on the contrary, the fruits are much smaller, and wings therefore more suitable. Possessing in themselves the means of dispersal, they have no need of offering any attraction to animals. In fact every one which is eaten is so much pure loss. Hence, while the shell of the Walnut is sufficiently hard to protect the seed from the severity of the weather, and from the attacks of most insects &c., which would not help in their dispersal, it offers no obstacle to larger animals. That of Pterocarya, on the contrary, is very hard and strong, and even the interior portion (the walls and pillars surrounding the four hollows) are of the same character, while in the Walnut they are, comparatively, quite soft.

One reason why the similarity of construction in the two seeds does not at first strike the observer, is that in Pterocarya the lobes of the seed evidently enter the pericarp ; in Juglans, on the contrary, the lobes are so much larger that it rather seems as if the pericarp sent projections into the seed.

That the present condition of the Walnut seedling is not original, we have interesting evidence in the presence of small leaves reduced to minute scales, as in the Oak and many other plants with subterranean cotyledons.

These scales evidently indicate the former presence of actual leaves which are now no longer required. The curious lobings and foldings of the seed in the Walnut also remind us of the time when the cotyledons were variously lobed and folded so as to occupy the whole space in the gradually enlarging seed. At present they seem to fulfil no useful function, except as a storehouse of nourishment for the seedling.

Seedlings.—Two very distinct types of seedlings may be noted in the Order, namely, those with subterranean cotyledons and those with aerial ones. The former are represented by Juglans regia (fig. 661). The hypocotyl is undeveloped, and the cotyledons remain enclosed in the bony endocarp during germination ; they develop petioles sufficiently long to enable the plumule to make its exit from the apex of the nut and grow upwards. The internodes of the stem between the aborted leaves noted in the seed attain a considerable length during germination. Four or five pairs of these scales occur before a perfect leaf is developed. The first perfect form consists of three leaflets; the second of five, and the third of four; but the number may vary according to the vigour of the seedling. The leaflets are serrated, with nerves running into the teeth, while those of the adult tree are entire, with the principal nerves incurved and not reaching the margin.

The cotyledons of Pterocarya caucasica are deeply bipartite, and each of the primary divisions again divided for more than half their length. The ultimate segments are oblong-linear. Three out of five nerves terminate at the base of a sinus, and the lateral ones of these fork, giving off a branch into each of the ultimate segments. The first five leaves are simple, lanceolate, acuminate and penninerved, while the ultimate ones are pinnate with numerous pairs of leaflets, and an odd one.

Juglans regia, *L.*

Pistil syncarpous, inferior, surmounted by the bract and bracteoles which are adnate to it, forming a small three- to five-toothed involucre. Higher up and inside of this involucre is the small four-lobed perianth.

Style very short, deeply bifid, with the two arms broadly linear-oblong, blunt, spreading and recurved, stigmatic all along the upper surface with wavy lamellæ.

Ovary of two carpels, one-celled, one-ovuled, with a small cavity just sufficient to accommodate the ovule in the quite young state; ovule basal, erect, orthotropous, in direct connection with the axial vascular tissue; micropyle superior.

Fruit an ovoid drupe surmounted by the beak-like remains of the style, densely pubescent in the young state at least, one-celled, one-seeded; exocarp fleshy, at length bursting irregularly, and falling off; endocarp woody, forming the shell of the nut, which is corrugated externally and deeply excavated or chambered internally making the fruit appear two- to four-celled, indehiscent, but separable into halves.

Seed deeply two- to four-lobed at the base, tapering upwards into a somewhat wedge-shaped but rounded or blunt point; testa membranous.

Embryo large, fleshy, colourless, conforming to the seed, and that again to the inner lining of the endocarp; cotyledons four-lobed and slightly auricled at the base, closely adpressed, wrinkled and appearing like one continuous piece, constituting the greater part of the embryo, subterranean in germination; radicle superior, close under the base of the style, very short, blunt, occupying the pointed apex of the seed, projecting from between the notches at the base of the cotyledons, somewhat compressed right and left, i.e. in the same plane as the cotyledons; plumule conical with a row of five minute buds or leaves along two sides and opposite to the cotyledons, with two perfect leaves each having about three leaflets alternating with them.

ORIGIN OF INTERNAL CAVITIES OF THE FRUIT.

A vertical section of a young fruit made on the 4th of June shows the exocarp already differentiated from the tissue within it and containing chlorophyll in its cells. The endocarp is colourless but contains plenty of protoplasm. Surrounding the central ovule, and projecting on each side from its base, is a layer of tissue of a watery appearance, and having little or no cell-contents, but perfectly unbroken.

A transverse section of another fruit, made about the same date, shows a similar but thin layer of watery tissue surrounding the ovule; and on one side of the latter, but extending more than half way to the periphery of the endocarp, are two irregular-shaped similar areas.

A vertical section of the fruit made on the 21st of June showed the watery colourless tissue greatly increased in bulk, and extending with two long branches nearly to the base of the endocarp, where they widen. The broader parts of this tissue are beginning to break up.

A corresponding transverse section shows four masses of watery or cortical parenchyma, with a cavity in the centre of each, formed by the breaking up of the cells which were originally continuous with the rest of the endocarp.

A longitudinal section of the fruit made on the 8th of July showed that the cortical and watery parenchyma had previous to this greatly increased in bulk and become dissolved. The testa has grown contemporaneously with the breaking up of the tissue of the ovary, and by continuously adjusting itself by growth to the interior of the cavity, now almost completely fills it including the various irregular hollows or excavations. The tissue of the nucellus has become deliquescent and watery, while as yet the embryo is extremely minute and difficult to detect.

A corresponding transverse section shows the four main cavities now formed in the fruit, together with several minor ones. The testa for some reason or other has not been able to develop to the bottom of some of the recesses, possibly on account of their being narrow. Some of the cavities are still in process of excavation, and the cortical matter is white while the rest of the endocarp is darker and slightly tinted with green. The interior of the seed is lined with jelly-like protoplasmic matter while the central hollow part is occupied with a liquid.

Seedling (fig. 661).

Primary root very stout, woody, tapering downwards, subflexuose, emerging from the apex of the nut, and furnished with lateral rootlets.

Hypocotyl very short, stout, woody, scarcely distinguishable from the root.

Cotyledons large, fleshy, obovate, bilobed, crumpled, filling the whole cavity of the seed and remaining there after the germination of the plant, attached to the young plant by their short fleshy petioles.

Stem woody, erect, stout, compressed, glabrous, whitish beneath the soil, deep green above and covered with little grey or brown lenticels; 1st internode 2·5 cm. long; 2nd 2·3 cm.; 3rd 1·8 cm.; 4th 2·5 cm.; 5th and 6th each 1·6 cm.; 7th 7 mm. These lengths vary according to the vigour of the seedling.

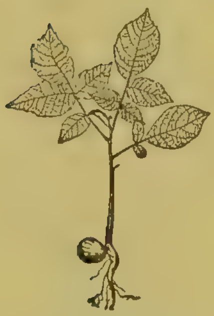

FIG. 661.
Juglans regia.
One-tenth nat. size.

Leaves compound, imparipinnate (first eight in specimen reduced to scales and opposite or subopposite in four pairs), cauline, alternate, exstipulate, petiolate, deciduous, glabrous except tufts of hairs in the forks of the veins on the under side of the leaves of the adult tree, deep green above, paler beneath, shining; leaflets penninerved, with alternate, ascending nerves incurved at their tips, alternate or subopposite, and frequently not evenly paired, the odd one when next the terminal leaflet apparently cut away from the base of the latter, making it unequal at the base, more or less regularly serrate in the young plant and quite entire in the adult tree; petioles subterete, tapering upward from a stout base, flattened on the upper side and slightly channelled, but in the adult tree terete and not flattened or channelled except at the dilated clasping base.

Nos. 1–8. Reduced to small alternate or nearly opposite scales.

No. 9. Trifoliolate; terminal leaflet large, obovate, or elliptic, cuspidate; lateral leaflets small, oblong, alternate.

No. 10. Five-foliolate; terminal leaflet oblong-obovate; middle pair ovate, acuminate, oblique on the anterior basal side, unequal, subopposite; basal pair small, unequal, ovate, oblique on the anterior basal side.

No. 11. Four-foliolate; leaflets alternate, all unequal; terminal one ovate-oval, subacuminate, very unequal at the base; the other three leaflets ovate, subacuminate, oblique on the anterior basal side, much smaller than the terminal one.

The serrate character of the primary leaves of the seedling is very noticeable, as well as the fact that all or nearly all of the primary or stronger lateral veins run to the tips of the teeth.

Ultimate leaves imparipinnately three- to nine-foliolate; leaflets alternate or sometimes subopposite, unequal in size, entire, oblique on the anterior basal side; terminal leaflet much the largest, oblong-elliptic, cuspidate; lateral leaflets oblong or ovate-oblong, obtuse or cuspidate or subacuminate, gradually smaller towards the base of the leaf.

M. Flèche has pointed out[1] that the young leaves differ in being more acuminate, with nerves running to points, and altogether more like those of some species of Carya.

Juglans nigra, *L.*

Ovary one-celled or partly four-celled at the base and apex, one-ovuled; ovule as in J. regia.

Fruit globose, one-celled, or nearly four-celled by the projection of ribs of the endocarp into the interior from the base and apex, green, covered externally with little warts and sessile glands, tipped with the persistent remains of the style and the superior perianth; epicarp fleshy; endocarp bony, thick and projecting very much into the interior of the fruit, with numerous shallow cavities on its inner face; placenta basal, one-seeded.

Seed solitary, erect, deeply four-lobed; lobes reniform or transversely oval, constricted at their union with the central body of the seed, projecting into each of the four large cavities of the ovary, and raised into numerous gibbosities or swellings to conform to the interior; testa marked with numerous long, forking veins proceeding from the basal chalaza and radiating all over the lobes to the radicle, white or creamy yellow, double; tegmen paler, thinner.

Endosperm absent in the mature seed, but in the young state filling all the interior of the ovule with a clear, jelly-like mass on the top of which the cotyledons lie astride with the radicle close to the apex, and therefore distant from the hilum.

Embryo straight, colourless, fleshy, ultimately occupying all the

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[1] *Bull. Soc. des Sciences*, Nancy, 1886.

interior of the seed; cotyledons bilobed and the lobes again bifid with the secondary segments entire or emarginate (in the immature state), slightly auricled at the base; radicle short, stout, triangular, pointed.

Pterocarya caucasica, *C. A. Mey.*

Fruit sessile, inferior, tipped with four tooth-like perianth-segments, seated in the axil of a small bract, which for more than half its length is adnate to the anterior part of the fruit, with two oblique wings consisting of two enlarged bracteoles adnate to and enclosing more than half of the fruit.

The wings are obliquely attached to the fruit owing to its ascending direction, and themselves ascend vertically towards the apex of the spike, diverging laterally until they meet those of the contiguous row of fruits on each side.

Ovary of two carpels, one-celled, but partly two- to four-celled, especially in the lower part; ovule orthotropous, on an elevated, but really basal placenta formed by the infolding and union of the margins of the carpels.

A transverse section of the ovary near the base shows four cavities which in the early stage of the fruit are not empty but filled with light, white, spongy or cortical material, becoming dry, brown and easily crushed into little space when the testa of the seed develops.

The young fruit when examined about the last week of May shows the pistil, subtended at the base anteriorly by a small bract, and at the sides by two bracteoles adnate to its base. Perianth leaves four, inserted on the neck of the pistil a short way beneath the two large spreading coarsely papillose stigmas. The cavity of the ovary is small and nearly filled by the minute ovule. The tissues surrounding the ovule are all coloured alike, and no cavities or cortical tissue are seen.

By the 11th of June all parts of the young fruit have increased very much in thickness, but not much in length. The ovule is much larger, with the distinctly discernible coat slightly overtopping it. The ovary is much wider, and at its base (in longitudinal section) are two whitish masses of tissue, definite in outline and almost colourless, as if the protoplasm had been removed, leaving nothing but water in the cells.

By the 25th of June the young fruit has increased greatly in both length and breadth. The bracteoles are larger, and the space between the base of the fruit and the ovule has elongated. The chief difference, however, is in the coat of the ovule, which is now twice as long as the nucellus, and wide open at the apex. The colourless tissue on each side at the base of the ovule has not much altered, but vascular tissue begins to make its appearance.

About the first week in July there seems no difference in the size of the ovule, but the fruit as a whole continues to grow rapidly. The bracteoles originally near the base of the fruit have been carried a long way up. The neck has also been shortened by the thickening of its basal portion. The vascular tissue has increased. Other and more important changes have also taken place. On each side of the ovule two oblong curved patches of tissue are seen lying about half way between it and the exterior of the fruit; these are losing colour in the same manner as the above-mentioned masses at the base of the ovule.

In transverse section colourless tissue, evidently becoming cortical, is seen to surround the ovule. On each side of the ovule towards the circumference of the fruit four irregularly circular pieces of colourless or cortical tissue are seen. The ovule is oval in outline in the transverse section. The framework of the fruit, which ultimately becomes sclerenchymatous, already commences to show itself.

The ovule by the 23rd of July has increased but little in size, but differs somewhat in shape from that of earlier stages. The principal alterations are in the cortical tissues. In longitudinal section a large oval or elliptic mass of cortex is seen on each side of the fruit, mostly above the level of the ovule and close to the rind. Two large masses also extend from the ovule downwards towards the base of the fruit. Bounding all these masses are bands of tissue that ultimately become sclerenchymatous. The cortex is as yet solid. The cavity of the ovary is small. The bracteoles forming the wings have grown nearly to the top of the fruit on the posterior side, while they descend towards the base on the anterior side.

In the transverse section at this stage four masses of cortex are seen, two on the right and two on the left.

A longitudinal section of the fruit about the 6th of August shows two longitudinal masses of cortex and a transverse piece, lying as it were across the top of the two. All are separated by a framework of vascular and sclerenchymatous tissue, or tissue rapidly becoming sclerenchymatous.

In the transverse section in a much more advanced state taken at the very base of the ovary, a central line of small solid masses of cortex is seen. Right and left the usual four masses of cortex have now become almost completely absorbed, leaving strands and broken pieces running across the cavity.

In a corresponding vertical section through the axis of the fruit, the ovary, together with what used to be two longitudinal masses of cortex, have become one continuous cavity. The cortex is not yet wholly absorbed, but lines the sides of the cavity. Two masses of cortex show themselves mostly above the ovary, one on each side; but they are still solid. The ovule is flask-shaped, but still very small. The vascular and sclerenchymatous tissue is getting very firm.

On the 18th of August the ovule has increased so as to fill the whole cavity of the ovary. A longitudinal section through the axis shows two masses of cortex on the upper side. In a corresponding transverse section the ovule again nearly fills the cavity. Four solid masses of cortex are seen, two right and two left of the axis.

In a transverse section taken lower down than the last and corresponding to it in age, the connection of the ovary cavity with the four cavities formed by the absorption of cortical tissue is seen. Across the opening of some of the cavities strands of cortical tissue still remain.

In a transverse section made on the 1st of September, the seed filled the cavity of the ovary and lay nearly at right angles to its usual position with regard to the axis. The two cotyledons of the young embryo were seen lying in the middle. Some masses of solid cortex may still be seen at this date. A corresponding longitudinal section shows the embryo, the cotyledons of which are already four-lobed. The seed has descended into the basal cavities. The hard sclerenchyma has now greatly increased in thickness, making a framework for the fruit and rendering it hard and brittle.

A longitudinal section of a barren fruit, made on the 12th of September, showed the small flask-shaped ovule, and the nearly empty cavities at the base of the ovary cavity. Some solid masses of cortex appeared both above and below the ovary.

By the 19th of September the embryo has greatly increased in size, filling the seed, which nearly occupies the whole of the space in the ovary cavity, and also the cavities extending below the latter. Lobes of the cotyledons are seen to descend into these basal cavities. These cavities are not yet completely filled with the lobes of the seed.

A transverse section through the fruit and seed at this date showed the embryo more advanced than in the last case, and the cotyledons very much plaited or folded. Above and at the sides of the ovary the cortex never becomes absorbed so as to form cavities like those four pieces beneath the ovary. Four large pieces may be seen, two on each side of the seed, and still quite solid.

In a transverse section of the fruit made below the base of the ovary, the four cavities are seen to be filled with the twisted or folded lobes of the cotyledons.

A longitudinal, but slightly oblique, section through the fruit was made on the 12th of October. Owing to the cotyledons being much folded and twisted, a clear idea of their arrangement can scarcely be obtained in longitudinal section. The radicle is seen at the apex of the seed which is orthotropous. At the base of the cavities formed by the absorption of cortex, the tips of the cotyledonary lobes in some instances appear to be folded transversely. A mass of cortex occupies the apex of the fruit. By this date it had not been fully matured and had been damaged by frost; that is, the exterior parts such as the rind and wings.

In a transverse section of the same date the cotyledonary lobes are seen to be variously folded in the same fruit.

Masses of cortex occur in various parts of the fruit, embedded in the more solid and sclerenchymatous endocarp. They are doubtless intended to lighten the fruit, and aid in its dissemination by means of the wind. The wings formed by the adnate and accrescent bracteoles, and the very thin rind or exocarp of Pterocarya, all point to the natural means of dispersing the fruit in this genus.

Seedling (fig. 662).

Hypocotyl erect, terete, brownish and glabrous in the lower part, greenish upwards and thinly pubescent, about 3 cm. above the soil.

Cotyledons bipartite, with the primary divisions narrowing to a cuneate base, and again deeply bipartite, making in all four linear-oblong, obtuse, entire, diverging and recurved segments, five-nerved from the base of the lamina, glabrous, dull opaque-green above, paler beneath; midrib slender, short, ending at the base of the middle fissure of the lamina; middle nerve on each side of the midrib strong, running along the middle of the primary divisions of the cotyledons and ending with a slender point at the base of their fissure, at the same time giving off a strong lateral nerve on each side a little below the apex, which runs along the middle of the ultimate

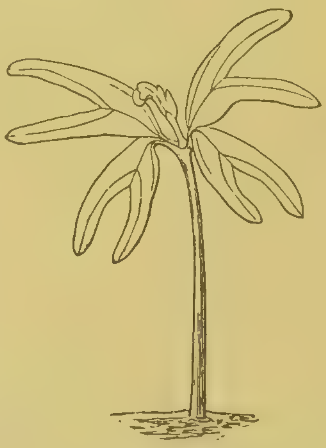

FIG. 662.
Pterocarya caucasica.
Nat. size.

segments; slender nerves run from the base of the lamina near the outer edge more than half way towards the apex; petiole short, deeply grooved above, convex on the back, glabrous, about 2·25 mm. long; lamina 1·5–1·8 cm. long, 2·3–2·5 cm. wide between the tips of the outer segments.

Stem erect, terete, glabrous or thinly pubescent, green, ultimately woody; 1st internode 2·25 mm. long.

Leaves compound, cauline, alternate, exstipulate, petiolate, imparipinnate, penninerved; leaflets serrate, numerous.

No. 1. Oblong or lanceolate, obtuse or acute, rather distantly serrate, simple, sessile or subsessile, glabrous or nearly so, alternately penninerved, with a nerve running into each serrature.

Nos. 2–5. With more elongated petioles, lanceolate, acuminate, larger, but otherwise similar to the first.

MYRICACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 400.

Fruit and Seed.—The ovary is one-celled with a solitary, basal, erect, orthotropous ovule. The fruit is small, globose or ovoid, with a fleshy or succulent exocarp and a bony endocarp. The seed is erect and exalbuminous with a membranous testa. The embryo is straight, with fleshy plano-convex cotyledons and a short superior radicle, the whole conforming in shape to that of the seed.

Seedling.—Myrica californica (fig. 663) may serve as a type of the Order. The cotyledons are spathulate-obovate, tapered to the base, with several slender, ascending nerves on each side of the midrib, best seen when fading. The first leaf is small and cuneate, followed by three which are cuneate or rhomboid, trifid and serrate. The fifth and sixth are narrowly ovate; and the seventh to the tenth inclusive are oblong and acute. The primary leaves as well as the cotyledons bear a strong resemblance to those of Cratægus Oxyacantha, but they are covered with oily or resinous glands. The roots are plentifully supplied with small tuberous processes.

Myrica californica, *Cham. et Schl.* (fig. 663).

Primary root long, tapering, flexuose, with numerous lateral rootlets, and furnished here and there with small fleshy tubercles or nodosities.

Hypocotyl terete, glabrous, red, soon becoming woody.

Cotyledons spathulate-obovate, suddenly narrowed to a subacute apex, gradually tapered to the base, sessile, glabrous, with a distinct midrib and several slender nerves ascending from near the base (probably best seen when the cotyledons are fading), reticulated towards the apex, 9 mm. long, 4 mm. wide.

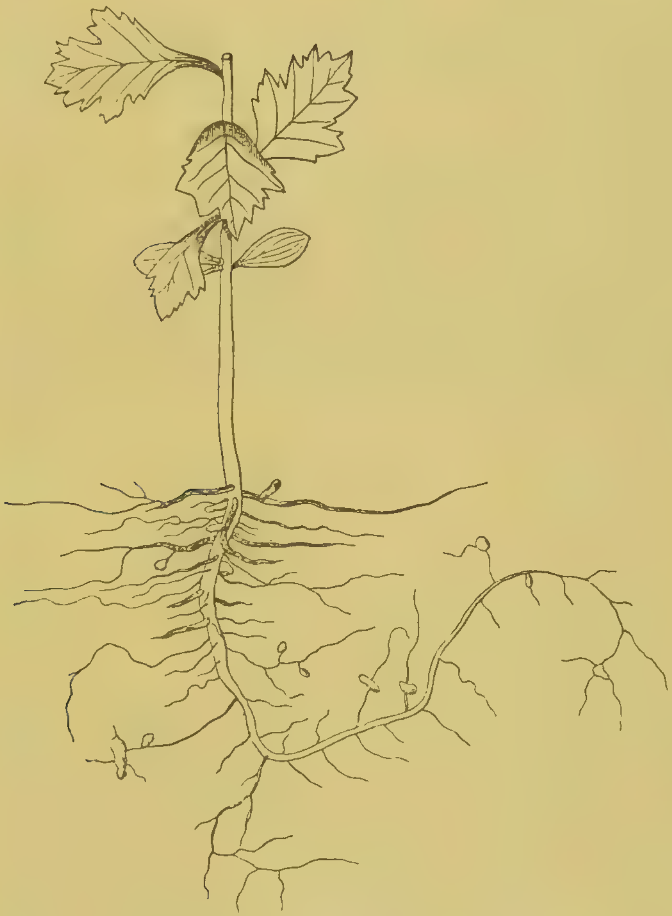

Fig. 663.—*Myrica californica.* Nat. size.

Stem erect, terete, hairy, glandular, red, soon becoming woody; 1st internode 6·5 mm. long; 2nd 4 mm.; 3rd 7 mm.

Leaves simple, cauline, alternate, exstipulate, petiolate, alternately penninerved, thinly hairy above, but more especially on the upper side of the petiole, and densely covered with small oily glands on the upper surface, most distinctly visible when young; petiole semiterete, flat above, somewhat dilated at its insertion on the stem.

No. 1. Narrowly cuneate, serrate above the middle.

Nos. 2–4. Cuneate, or subrhomboid, shallowly trifid and serrate, similar to the leaves of the common Hawthorn (Cratægus Oxyacantha.

Nos. 5 and 6. Narrowly ovate, cuneate at the base, irregularly and slightly doubly serrate.

Nos. 7–10. Oblong, acute, cuneate at the base, sharply and somewhat doubly serrate.

The seedling bears considerable resemblance to a young Cratægus or Prunus, both in the cotyledons and leaves. It also resembles a young Betula, but the cotyledons are much larger, and the leaves from the seventh onwards become oblong. The glands on the stems and leaves, the penninerved venation and the oblong leaves from the seventh onwards are however characteristic of Myrica. The small tubercles on the roots recall those of Alnus cordifolia amongst the Cupuliferæ.

CASUARINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 401.

Fruit and Seed.—The ovary is very small with twin, collateral, ascending, semi-anatropous ovules, having a superior micropyle. The fruits are ovoid or cylindrical, covered with accrescent bracts and bracteoles, and arranged in a dense cone-like head. The nut is laterally compressed, produced into a wing running along the sides of the style and indehiscent. The seed is solitary by abortion and exalbuminous. The embryo is straight with flattened cotyledons and a superior radicle.

Seedling.—The cotyledons of Casuarina Cunninghamiana (fig. 664) are oval, obtuse, and sessile. The stem is quadrangular in the seedling stage. The first two leaves are opposite, followed by at least nineteen whorls of four leaves each, decussating and forming the angles of the stem. They are adnate to the stem for the greater part of their length and free at the tips only. In this respect they bear a strong resemblance to the Equisetaceæ and some of the Coniferæ.

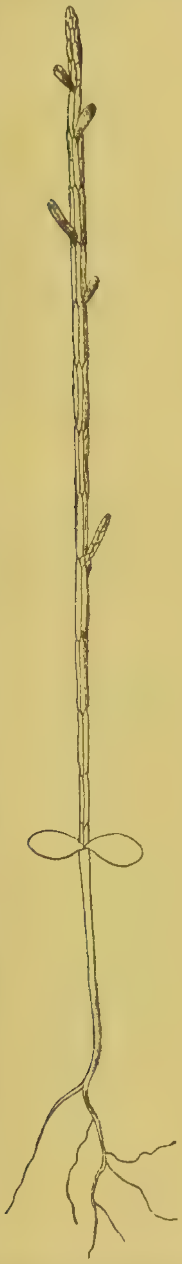

Fig. 664.—*Casuarina Cunninghamiana*, × 2.

Casuarina Cunninghamiana, *Miq.* (fig. 664).

Primary root slender, wiry, flexuose, with similar lateral fibres.

Hypocotyl erect, terete, glabrous, wiry, deep shining brown, very slender, 6·5 mm.–2·1 cm. long.

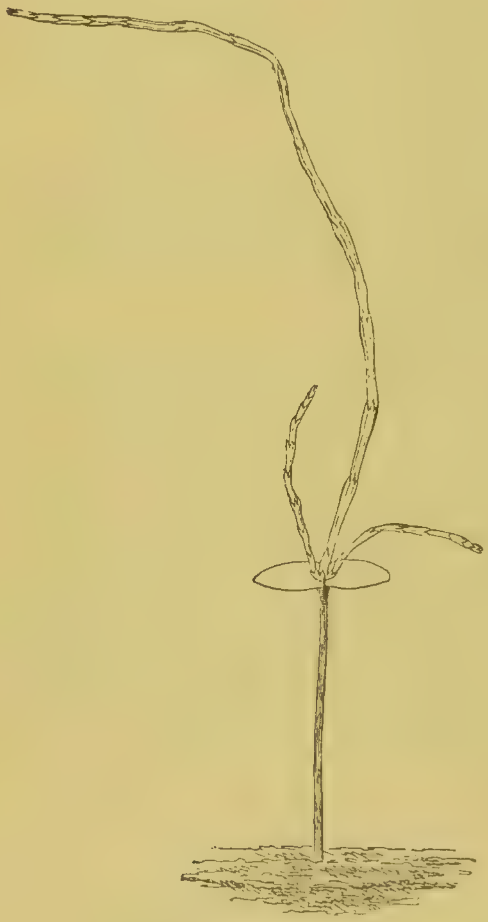

Fig. 665.—*Casuarina stricta*. Nat. size.

Cotyledons oval, obtuse, entire, sessile, glabrous, with a midrib slightly discernible on the under side by transmitted light, deep green above, paler beneath, 3–4·25 mm. long, 1·5–2·5 mm. wide.

Stem erect, quadrangular in the seedling stage, glabrous, and entirely covered by the decurrent and adnate bases of the leaves, deep green, ultimately woody; 1st internode undeveloped and all the rest very short.

Leaves simple, entire, cauline, verticillate, exstipulate, sessile, wholly adnate to the stem except the small tooth-like tips, glabrous, deep green, with pale margins to the tooth-like tips, without any discernible venation, the whorls alternating one with another, and by so doing forming the short alternating angles of the stem which correspond with the lengths of the decurrent leaves and the internodes.

Nos. 1 and 2. Very short, opposite, almost arising from the same level as the cotyledons and followed by nineteen whorls consisting each of four leaves, forming the angles of the stem, and decussating or alternating one with another, with very minute free tips.

Casuarina stricta, *Ait.* (fig. 665).

Hypocotyl erect, terete, rising about 3 cm. above the soil.

Cotyledons ovate-oblong, sessile, connate, and appearing perfoliate, narrowed upwards to an obtuse point, horizontal, 7·5 mm. long, and 3 mm. wide.

Stem erect, ridged and furrowed, owing to the base of the scale-like leaves being decurrent upon it; 1st internode very short; 2nd and 3rd 8 mm. long; 4th to 6th 9 mm.; succeeding ones shorter. The stem and branches are articulated much like those of an Equisetum, and the branches or the smaller ones ultimately become disarticulated and fall like deciduous leaves.

Leaves simple, cauline, whorled, with the whorls decussating, reduced to small scales, sometimes more or less connate at the base and sheathing the stem, the midribs decurrent upon the latter forming slender ridges, those above alternating with those below each whorl. The number of leaves in a whorl varies from four to many, according to the thickness of the young shoots bearing them.

CUPULIFERÆ.

Benth. et Hook. *Gen. Pl.* iii. 402.

Fruit and Seed.—The ovary is inferior, and during the period of flowering often appears quite solid, but after fertilisation it becomes more or less perfectly two- to three-celled, rarely four- to six-celled. The ovules are solitary in each cell or twin and collateral, inserted at or near the apex of axile placentas, pendulous and anatropous or nearly so, with a superior micropyle. The fruit is a one-celled nut and variously surrounded or included in a cupule consisting of bracts or bracteoles more or less cohering or grown together. The shell of the fruit is crustaceous or woody and indehiscent. The seed is most often solitary by abortion and exalbuminous with a membranous testa. The cotyledons are fleshy or much folded and foliaceous, while the radicle is short and superior.

About five more or less distinct types of seeds have come under my observation. The fruit or nut of Carpinus Betulus (the Hornbeam) is ovate, and the solitary pendulous seed is obovate. The embryo is straight and fleshy, with obovate, entire, or emarginate cotyledons. The emargination is due to the fruit being occasionally more markedly umbilicate than usual at the base with the wall projecting into the cavity at that point. The short radicle projects slightly beyond the cotyledons.

A second type occurs in Corylus Avellana (the Hazelnut) (fig. 668) which in the wild state has a more or less globose fruit surrounded by a leafy cupule. The cultivated Cobs and Filberts, varieties of this species, have much larger and more or less oblong fruits. The seed conforms to the interior, is solitary and suspended from the apex of a filamentous, originally axial placenta. The young ovary is two-celled, but the septa become ruptured and lost at an early stage, leaving the placenta free. The latter gets pushed against the sides of the pericarp, and is curved, like the seed, in conformity with its outline, and bears the remains of three aborted ovules at its apex, besides a perfect seed. In some botanical text-books the filamentous placenta is spoken of as the raphe. Strong slightly forked nerves radiate from the chalaza all over the testa towards the micropyle. The raphe and chalaza are ventral and next the cord-like placenta. The embryo is fleshy with plano-convex or hemispherical cotyledons enclosing the small plumule and the short superior radicle. The seed of Corylus Colurna is more ovoid and somewhat compressed, with the embryo conforming to the interior. The cotyledons are plano-convex, and obovate, but in all other respects this species conforms to the type.

The fruit or acorn of Quercus pedunculata (fig. 669) is oblong, one-celled and one-seeded. The cotyledons are fleshy, oblong, obtuse or slightly emarginate owing to a thickening at the chalaza, and auricled at the base; but the auricles fit closely to one another, hiding all but the extreme tip of the short radicle. The fruit is surrounded at the base by a scaly, cup-shaped involucre. In the earliest stages it is a three-celled ovary with two ovules in each cell suspended from near the middle of the axial placentas. Soon after fertilisation one ovule develops at the expense of all the others, pushing them aside as well as the placentas, so that at this stage the ovary in either transverse or longitudinal section appears lopsided. The septa become ruptured or destroyed and the placenta-bearing axis gets severed from the apex of the ovary and ceases to lengthen. The ovule in the early stage is pendulous, and anatropous with the hilum a little below the top. As the ovary increases in length and the axial column gets torn from the top, the young seed increases in length much faster above than below its attachment, till in the full-grown state it is practically orthotropous. The chalaza is basal and gives off numerous, strong, branching veins radiating all over the testa up to the micropyle. It is really very close to the hilum owing to the extreme shortness of the raphe (see diagram, fig. 669). The seed is sessile and the axial column really very short and firmly squeezed against the base of the ovary by the seed which completely fills the cavity.

A fourth type is represented by Castanea vulgaris (the Chestnut) the fruits of which are generally grouped three together within a four-leaved bristly involucre. The ovary consists of six to nine carpels, uniting to form as many cells with a pair of pendulous anatropous ovules in each cell. It soon becomes one-celled by the rupture of the placentas, and one, rarely two, seeds develop at the expense of the rest. The ovary is densely lined internally with silky hairs. The seed is ovoid or triangular-ovoid according to the pressure brought to bear upon it by others. The cotyledons become concave towards one another at an early stage, and ultimately fleshy, occupying the whole of the seed, wrinkled both internally and externally, undulate and interlocking with one another at the margin.

Fagus sylvatica (the Beech) constitutes a fifth type. The cupule consists of numerous bracteoles amalgamated in four large pieces which completely enclose the two to four, generally two fruits, and ultimately spread open to allow of the dispersion of the latter, which are triquetrous with three wings extending from the apex to below the middle. The seed is bluntly trigonous and does not completely fill the angles of the fruit. The fruit is three-celled in the ovarian stage, with two anatropous ovules suspended from near the apex of each cell. In nearly every case one ovule develops at the expense of the rest. The ovary soon becomes one-celled by the rupturing of the septa ; but the axial column remains attached to the apex of the cavity and carries the anatropous seed suspended from near the apex. The embryo at an early stage becomes doubled upon itself longitudinally and covers two of the sides of the triangular cavity. Then growth continuing at the edges of the cotyledons the primary folds are pushed into the centre of the cavity. The edges of the cotyledons become reversed towards the angle of the ovary occupied by their middle portion ; and when they have grown in this direction till they again meet with resistance, they double back again so that in the full-grown seed they consist of four folds so arranged as to fill the trigonous seed and that again the triquetrous fruit. They can therefore become aerial and green during germination, and differ in these respects from any of those mentioned above.

The greater number of the fruits of this Order are adapted to be transported by animals, to which they serve as food. Those of the Hornbeam, however, are winged.

Seedlings.—Four more or less distinct types coming under my observation have aerial cotyledons, while in a fifth case they are subterranean during germination. The simplest type is that of Betula alba (fig. 672) which has small, oblong-ovate, shortly stalked cotyledons, showing a faint midrib. The first two leaves are ovate, followed by three more or less triangular ones. The sixth is cordate. All are unequally serrate and penninerved with the basal pair of nerves the strongest. The leaves of the adult are doubly serrate or even somewhat lobed.

The cotyledons of Alnus cordifolia (fig. 666) are oblong-oval, entire, and obscurely trinerved at the base. The first two leaves are broadly ovate; and the three following ones are more or less cordate and broad; all are serrate. The cotyledons of Alnus incana laciniata differ in being broadly oval, emarginate, and faintly showing a midrib. The first leaf is broadly cuneate and coarsely serrate.

Carpinus Betulus (fig. 667) is very distinct from any of the above, and has roundly obovate, shortly petiolate cotyledons distinctly auricled at the base of the lamina. The first leaf is broadly triangular, lobulate and serrate; the second is ovate-subcordate; and the third ovate. All have a penninerved venation, but this is particularly well marked in the adult leaves, which are also plicate, and finely doubly serrate.

One of the most striking types in the Order is that of Fagus sylvatica (fig. 671) which has large, foliaceous, transversely oval and sessile cotyledons, auricled at the base, and longitudinally plicate, with many radiating forking veins, branching from two primary ones and spreading over the lamina in a fan-shaped manner. The lamina further is entire or obscurely crenate along the apical margin, and is 1·7–3 cm. long and 3–4·7 cm. wide. This peculiar shape and great size is due to their being membranous and much folded in the seed so as to occupy the whole interior of the triquetrous fruit to which the trigonous seed conforms. The first two leaves are opposite, ovate, obscurely dentate, penninerved, with the veins slightly incurved at their tips or running into the marginal teeth. The third leaf is alternate, broadly ovate, obscurely crenate, much smaller than the first two, and generally terminates the first season's growth.

The cotyledons of Quercus Ilex (fig. 670) are oblong, plano-convex, fleshy and subterranean. They are auricled at the base and petiolate, and although the pericarp splits longitudinally when they swell during germination, they never quit the acorn. The first five leaves are linear-subulate, minute, scarious, brownish and caducous. The sixth is somewhat larger, cuneate and trifid at the apex; the seventh and eighth are foliaceous but small. The ninth is much larger, lanceolate-oblong, and distantly serrate. The tenth to the thirteenth inclusive are elliptic-oblong, irregularly penninerved and acutely serrate. The above characters of the primary leaves vary according to the vigour of the seedling and the conditions under which germination takes place. The primary internodes have not the power of elongating, so that when an acorn happens to be deeply buried with dead leaves in a wood or plantation the primary leaves are arrested in growth and scale-like, while those leaves or most of those (probably never all) which reach the light become green and foliaceous. The leaves of the adult tree are mostly quite entire except in the variety Q. I. serratifolia.

The cotyledons of Q. pedunculata are also subterranean. Several of the primary leaves are reduced to scales as in the last case and probably for the same reason. The first green and foliaceous leaf is obovate-oblong and shallowly lobed at the top. Succeeding ones are obovate or obovate-oblong, and irregularly lobed with alternate nerves running into the lobes. The cotyledons of Corylus are also subterranean.

Alnus cordifolia, *Ten.* (fig. 666).

Primary root tapering, flexuose, with a few small lateral rootlets knotted with sessile tubercles.

Hypocotyl woody, erect, terete, finely pubescent, brown, 1·75 cm. long.

Cotyledons broadly oblong or oblong-oval, obtuse, petiolate, glabrous, rather fleshy, obscurely trinerved at the base, pale green; lamina 7·5 mm. long, 5 mm. wide; petiole grooved above, rounded and slightly pubescent on the back, 2 mm. long.

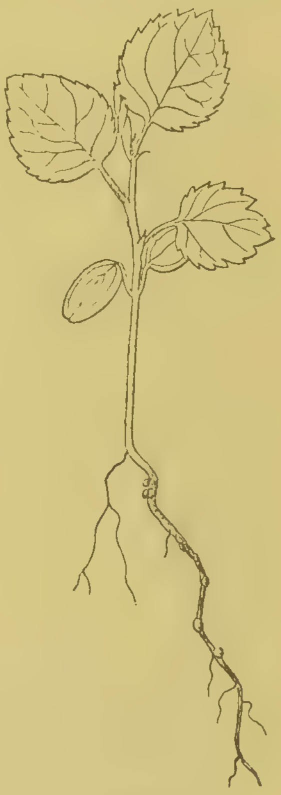

FIG. 666.
Alnus cordifolia.
Nat. size.

Stem woody, erect, terete, pubescent, brown; 1st internode 4·25 mm. long; 2nd 3 mm.; 3rd 3·25 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, thinly scaly above, floccose along the midrib and base of principal nerves with dirty white hairs, otherwise glabrous, deep green and shining above, paler beneath, alternately penninerved, finely reticulate; petioles terete, glabrous, obsoletely channelled on the upper side, scaly when young, tapering upwards from a stoutish base; stipules lanceolate, acute, scaly on the back, soon becoming revolute and caducous; leaf-buds viscid.

Nos. 1 and 2. Small, broadly ovate, acute, or cuspidate, irregularly and acutely serrate, slightly unequal at the base.

No. 3. Broadly subcordate, acute, irregularly and acutely serrate.

Nos. 4 and 5. Ovate-subcordate.

Ultimate leaves cordate, obtuse, cuspidate, minutely and mucronately serrate-dentate; larger nerves subincurved.

Carpinus Betulus, *L.*

Ovary of two carpels, one-celled or imperfectly two-celled in a very young state, with two ovules in one or both of the cells; ovules pendulous, anatropous; micropyle superior, close to the hilum.

Fruit a nut, ovate, compressed, umbilicate at the base, tipped with the persistent, superior, perianth-segments (which are unequal in size and irregular in number), strongly eight- to nine-ribbed, glabrous, green, ultimately yellowish; endocarp bony; pericarp thin, brown, membranous.

Seed obovate, compressed, pendulous from the top of the cavity, entirely occupying the interior of the nut, and conforming to its shape; radicle superior, close to the hilum; raphe ventral on one edge of the seed, sometimes removable; chalaza ventral, a little above the base on one angle, sending off a nerve to the base which forks there, one branch passing along each side of the apex of the cotyledons, besides four on each face of the seed which occasionally fork. These nerves however are not always constant in number, and may be different on the two sides of the same seed.

Embryo straight, large, and occupying the whole of the interior of the seed to which it conforms; cotyledons obovate or oval, applied face to face, colourless, shining, fleshy, slightly convex on the back, entire at both ends, or sometimes emarginate at the apex; radicle superior, slightly protruded beyond the cotyledons.

Seedling (fig. 667).

Primary root short, tapering, dark-coloured, giving off small wiry rootlets, flexuose.

Hypocotyl erect, terete, soon becoming woody, flexuose, shortly pubescent, brownish, 3–4·5 mm. long.

Cotyledons rotund-obovate, obtuse, shortly petiolate, auricled at the base, concave on the upper face, rather fleshy, green and rising above the soil, glabrous except the petiole, which is short, slightly grooved on the upper side and pubescent, 1·5 mm. long.

Stem soon becoming woody, erect, terete, zigzag from leaf to leaf, pubescent; 1st internode ·75 mm. long; 2nd 1·5 mm.; 3rd 3·5 mm.; 4th 2·25 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, glabrous except on the nerves beneath and the petioles, penninerved with ascending parallel nerves running into the serratures, plicate, especially when young, doubly and cuspidately acuminate, serrate; petioles slender, channelled above, short, pubescent; stipules free, subulate, acute, hairy, brownish-green.

No. 1. Triangularly ovate, lobulate and doubly serrate, with acute serratures.

No. 2. Ovate-subcordate, acute, doubly serrate.

No. 3. Ovate, acute, narrowed slightly at the base, but rounded, doubly serrate.

Ultimate leaves ovate, acuminate, doubly serrate, slightly unequal at the base, plicate, with ascending parallel nerves, glabrous above, sparsely hairy on the nerves beneath with a woolly tuft in the axils of the lateral veins where they join with the midrib, petiolate; petioles terete, hairy, tapering upwards from a stout base, 8–12 mm. long.

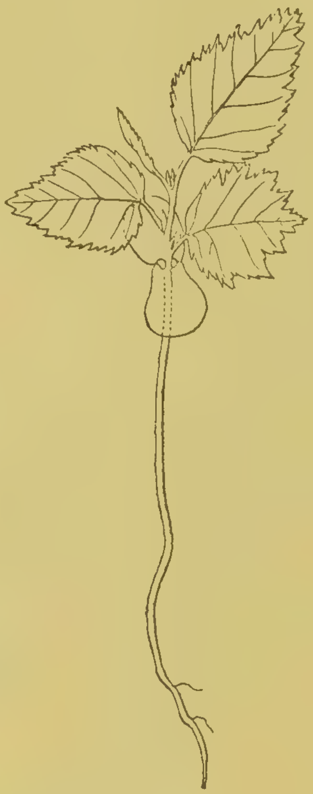

FIG. 667.
Carpinus Betulus. Nat. size.

Corylus Avellana, *DC. f.* (fig. 668).

Ovary of two carpels, two-celled, each cell two-ovuled; ovules pendulous, anatropous; micropyle superior.

Fruit a glans or nut surrounded at the base by an involucre which is double (the outer series or bracts being short and little cut, the inner or bracteoles large, accrescent and deeply laciniated), oblong-ovoid, ovoid or globose, glabrous except at the top which is densely and finely

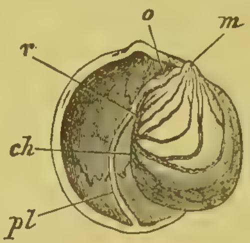

FIG. 668.—*Corylus Avellana.* Vertical section of nut, nat. size, with seed pulled out: *o*, aborted ovule; *m*, micropyle; *pl*, placental axis; *r*, raphe; *ch*, chalaza.

pubescent, and marked with two scars showing the remains or trace of the perianth, and indicating the bicarpellary nature of the fruit, indehiscent, one-celled, one-seeded, with remains of three aborted ovules, one of which in some rare instances seems to have been fertilised and grown to some size; pericarp woody, lined internally with brown spongy and scaly matter.

Seed globose or otherwise conforming to the shape of the pericarp, suddenly narrowed to a short point at the apex, pale yellowish-white, strongly marked with diverging simple or slightly forking veins radiating from the chalaza to the micropyle; raphe about 3·5 mm. long, ventral and next to the cord-like placenta arising from the base of the fruit and passing along the side of the seed (cf. Quercus); hilum lateral a little below the apex; micropyle and radicle superior; testa thin, membranous.

Embryo straight, occupying the whole interior of the seed, fleshy, yellowish-white; cotyledons plano-convex, thick, oily, each occupying half of the seed, semi-orbicular, cuspidate at the apex, or oblong-cuspidate; radicle small, superior; plumule small.

Germination.—The thick cotyledons remain in the fruit, and are not carried above the soil. The plumule forces itself out of the nut and develops hypocotyl and rootlet. The cotyledons gradually become aborted; at their outer side are seen two yellow swellings (rudimentary stipules) which also remain in the earth.

Quercus pedunculata, *Ehrb.* (fig. 669).

EARLY DEVELOPMENT OF FRUIT AND SEED.

When the acorn and cupule together equal the size of a pea, all the ovules are of equal size and decidedly pendulous, oblong, obtuse at the lower and apical end, narrowed above the attachment with the micropyle prolonged into a small, obtuse, hooked point; the raphe is ventral; the chalaza apical and inferior; the hilum forming a longish attachment on the ventral aspect with no free funicle.

After fertilisation one ovule develops rapidly, becoming more or less broadly ovoid, attached to the axis along one side, with the subconical, obtuse, micropylar process still free and somewhat conspicuous. The cell containing this ovule is the only one that develops, containing the young seed and one aborted ovule. The other two cells of the ovary remain small and gradually become pushed on one side with their aborted ovules.

When the acorn has attained a diameter of 1·1 cm., and a length of 1 cm. including the withered styles, the young seed is still distinctly pendulous, but is now oblong-obovoid, apiculate, and the placenta remaining short, develops in length towards the apex of the fruit as the latter grows; the attachment with the small aborted ovules is now distinctly below its middle.

The embryo at this stage is suspended from the apex of the seed and shows a distinct, short, turbinate radicle, ·5 mm. long, with fleshy, lenticular, diverging, subtransparent, exauriculate cotyledons 2 mm. long and 2·25 mm. wide. The endosperm occupying the basal part of the seed is also subtransparent, soft and in a semi-gelatinous condition.

Pistil enclosed in an involucre or cupule, composed of imbricating bracts firmly cohering by their bases; ovary of three carpels, three-celled, with two ovules in each cell; ovules pendulous, anatropous, from the top of the cell with a prominent, projecting, superior micropyle.

Fruit an acorn or glans, ovoid or oblong, flattened at its junction with the receptacle, and umbilicate at the apex with the remains of the styles springing from the middle of the hollow, smooth, glabrous, shining, pale green, ultimately brown; perianth adhering to the ovary and with it forming the pericarp; seed free within the pericarp. By early rupturing of the septa the fruit becomes one-celled and one-seeded as the remaining five ovules are not fertilised, but become firmly pressed to the base of the ovary cavity by the large growing seed.

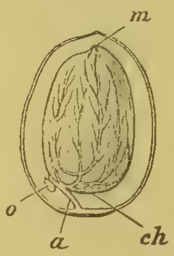

FIG. 669.—*Quercus pedunculata.*
Diagram of acorn and seed, nat. size: *o*, aborted ovule (pendulous, anatropous); *a*, axis elongated to show its nature; *ch*, chalaza; *m*, micropyle.

Seed large, filling the pericarp, ovoid-oblong, slightly oblique at the base and blunt at the apex; hilum basal; raphe very short or none (longer in Q. Ilex, at least in a younger state when the base of the seed is very oblique or even produced to a point); chalaza very conspicuous, giving off strong, radiating, longitudinal, forking, branching and anastomosing nerves which vary considerably; radicle apical, short, and just protruded from the cotyledons.

Endosperm absent.

Embryo straight, large, entirely occupying and conforming to the whole interior of the seed, which again conforms to the fruit, fleshy, pale yellow; cotyledons broadly oblong or suboval, plano-convex, with their flattened faces firmly applied to each other, entire at the apex or slightly emarginate owing to a prominence of the chalaza where it is attached to the embryo-sac, and most often with a shallow sinus, notched at the base of the inner face where the short radicle and small plumule are seated; plumule attached to the inner face of the cotyledons a little above the base.

Seedling.

Primary root and *hypocotyl* very similar to those of Q. Ilex.

Cotyledons in every respect similar to Q. Ilex, remaining in the nut and auricled at the base.

Several of the primary leaves are reduced to scales. First green leaf obovate-oblong, bluntly and shallowly lobate at the apex.

Succeeding leaves obovate or obovate-oblong, irregularly lobed, with strong ascending nerves running into the irregular lobes, glabrous except on the midrib above and the principal nerves beneath where they are pubescent, pale green, often suffused with brown.

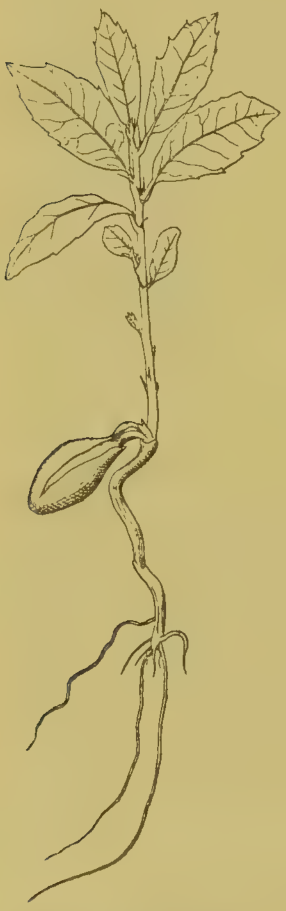

Fig. 670.—*Quercus Ilex.* Half nat. size.

Quercus Ilex, *L.* (fig. 670).

Primary root long, woody, flexuose, tapering, dark-coloured, wiry.

Hypocotyl woody, subterranean, very stout, dark-coloured, flexuose, more or less distinct from the root.

Cotyledons subterranean, thick, fleshy, applied face to face in the testa, and convex on the back, longitudinally wrinkled, obovate-oblong in outline, retuse at the apex, petiolate and produced behind the petiole into a thin appendage; petioles both curved to one side of the stem, about 1·2 cm. long; lamina including auricle 2·25 cm. long, 1 cm. wide.

Stem woody, erect, terete, somewhat zigzag from node to node, pale green, stellately pubescent, hoary when the tree attains some age; 1st internode 1 cm. long; 2nd–4th each about 1 mm.; 5th 5·5 mm.; 6th 2·5 mm.; 7th 1 cm.; 8th 1·75 mm.; 9th 5 mm.; 10th 2·5 mm.; 11th 2·5 mm.; 12th 3·5 mm.; 13th 2 mm. These lengths are liable to some variation in different seedlings, but they indicate the general tendency.

Leaves simple, cauline, alternate, stipulate, petiolate, evergreen, stellately pubescent on both surfaces, deep green and shining on the upper surface, ultimately glabrous there in the adult or old stage of the tree, and hoary with stellate pubescence on the under surface, penninerved, distantly serrate in the seedling stage, but nearly always quite entire in the adult tree; petioles short, terete, stout at the base, and tapering upwards, stellately pubescent; stipules linear-subulate, attenuate, dry, scarious, brownish, caducous.

Nos. 1–5. Small, scarious, brown scales.

No. 6. Very small, cuneate, tridentate at the apex.

No. 7. Small, oblong.

No. 8. Small, obovate.

No. 9. Lanceolate-oblong, distantly serrate, revolute and cartilaginous at the margin, 3·3 cm. long, 1·2 cm. wide.

No. 10. Elliptic-oblong, acute, distantly serrate.

Nos. 11–13. Elliptic-oblong, acute, acutely serrate.

The leaves of the typical form in the adult tree are oblong or ovate-oblong, acute, nearly always quite entire, revolute at the margin, deep green and shining above, hoary beneath with a stellate pubescence. Q. Ilex *var.* serratifolia has the leaves serrate even in the adult.

Castanea vulgaris, *Lam.*

Pistils generally three together, enclosed in a four-leaved involucre covered with a dense mass of compound stellately-branching bracts; ovary of six to nine carpels, six- to nine-celled with two ovules in each cell; ovules pendulous, anatropous; micropyle superior, a little above the hilum.

Fruit a nut, at first six- to nine-celled, but soon becoming one-celled and one-, rarely two-seeded, ovoid, compressed on the inner side of the two lateral ones, and on two sides of the middle one, glabrous at the base externally but silky towards the top, and densely lined internally with silky white hairs. Involucre opening to allow the indehiscent fruits to escape.

Seed triangular-ovoid, usually deeply furrowed longitudinally on the ventral side, radiately nerved from the radicle or micropyle downwards and slightly anastomosing; raphe ventral; hilum near the apex on the ventral aspect, and below the radicle.

Endosperm always thin, transparent, jelly-like, occupying all the lower part of the seed while the embryo is young, but ultimately all absorbed by the embryo, leaving the seed exalbuminous.

Embryo straight, fleshy, transparent white, ultimately large, occupying the whole interior of the seed, and then milky white, or yellowish externally; cotyledons from an early stage becoming concave, triangular or cucullate, conforming to the interior of the seed with the endosperm inside or between them. As they progress to maturity they develop along the base of the seed till they meet, with the last remains of the endosperm between them. They now become thicker, fleshier and more solid, wrinkled both externally and internally and undulate at the margin whereby they firmly interlock.

Germination.—The pericarp splits in the earth at the apex so that the shoot and rootlet can emerge and develop. The two large cotyledons rich in starch remain in the earth enclosed in the pericarp and are gradually absorbed. The first leaf is entire.

Fagus sylvatica, *L.*

EARLY DEVELOPMENT OF FRUIT AND SEED.

Pistil of three carpels and three-celled in the early stage with very hairy loose dissepiments becoming easily detached from a central, filiform, placental axis, traversing the whole length of the ovary and bearing the ovules near the apex.

Ovules two in each cell, making in all six, pendulous, anatropous; raphe ventral; chalaza basal; micropyle superior, elongated and projecting into the neck of the cell below the base of the styles, and considerably beyond the attachment of the ovule; hilum ventral, a little below the apex of the seed.

After fertilisation and when the nut has attained its full size or nearly so, one ovule only begins to enlarge rapidly while the others become shrivelled and brown. This ovule is narrowly oblong, pointed at the micropyle and obtuse at the apical and lower end, with a distinctly prominent raphe and chalaza. Owing to the rapid development of the ovary, the ovule is very short even after the nut has nearly attained its full size.

When the young seed has grown about half the length of the ovary or more it becomes oblong and trigonous, in conformity with the interior of the ovary.

The coarsely hairy lines seen on each side of the placental axis correspond to the original septa of the primarily three-celled ovary.

The embryo has its cotyledons already folded once in conformity with the trigonous character of the fruit. A little later on the cotyledons get too wide for the cavity of the fruit, and, continuing to increase, their edges become doubled back in two of the angles of the seed, and the folds thus produced have the effect of pushing the primary one right across the middle of the seed, and this position is retained permanently.

Fruit a one-celled, one-seeded nut, of which there are two to four, usually two, in an involucre, indehiscent, triquetrous, keeled from the top to below the middle, tipped with the hairy five- to six-lobed perianth and plumy remains of style, deep brown, shining, crustaceous, glabrous except at the top which is pubescent; by the early rupture of the septa the ovary becomes one-celled, while the axile placenta grows with it and equals it in length or nearly so. (Cf. Quercus.)

Seed strongly trigonous, or subtriquetrous conforming to the interior of the pericarp; testa thin, membranous, pale brown, marked with nerves proceeding from the chalaza to the micropyle, pendulous from the top of the cell, or rather from the placenta near the top; chalaza basal, distinctly elevated; hilum subapical or about 1 mm. below the apex, small; raphe long, running from the hilum along one face, or along one angle of the seed in a wavy manner.

Endosperm absent.

Embryo straight, large, entirely filling the seed when mature, and conforming to it in shape, colourless or pale yellow; cotyledons applied face to face, and plaited longitudinally, first with one large fold reaching from one angle of the cell to the middle of the flat face opposite, or in other words dividing the triangle in two equal halves; both cotyledons are then reversed on either side of the four folds forming the first division, and after proceeding backwards for some way are again turned forwards in the original direction, thus filling the other two angles of the seed.

Seedling (fig. 671).

Primary root long, stout, tapering downwards and after a time giving off freely short fibrous lateral rootlets.

Hypocotyl erect, stout, becoming more slender upwards, angled and furrowed, pale green, soon becoming brown, glabrous, 3–5·5 cm. long.

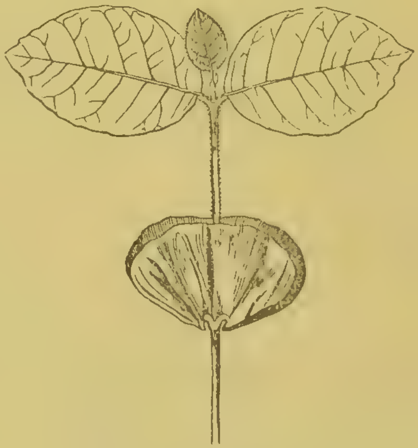

FIG. 671.—*Fagus sylvatica.* Half nat. size.

Cotyledons large, foliaceous, transversely oval, sessile, auricled at the base, with a fan-shaped venation, the nerves radiating and branching towards the margin from two main trunks, right and left of the axis of the plant, broadest along the upper edge and entire or obscurely crenate, glabrous, deep green above, white beneath, 1·7–3 cm. long, 3–4·7 cm. wide.

Stem erect, terete, hairy or pubescent when young, glabrescent, pale green, ultimately woody, arborescent; 1st internode 2·5–4·5 cm. long.

Leaves simple, cauline, alternate (first two opposite), stipulate, petiolate, alternately penninerved and finely reticulate, pubescent on both surfaces when young, glabrescent, shining on both surfaces, deep green above, paler beneath, deciduous; petioles terete, or nearly so, slightly channelled on the upper side, densely hairy, at least when young, comparatively short; stipules oblong-obtuse, narrow, pale brown, scarious, hairy, caducous.

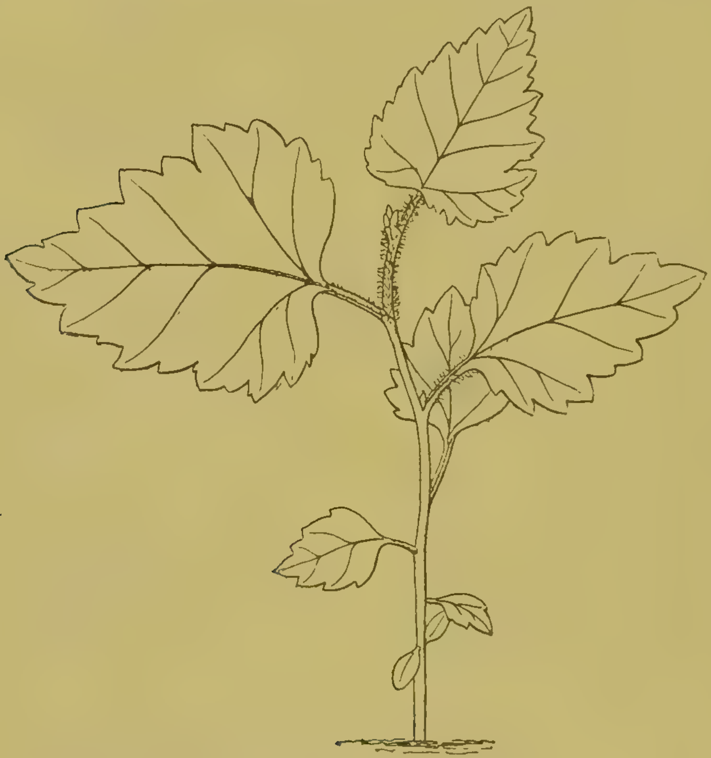

FIG. 672.—*Betula alba.* Nat. size.

Nos. 1 and 2. Opposite, broadly ovate, obtuse, obtusely crenate-serrate.

No. 3. Alternate, broadly ovate, obtuse, entire or obsoletely crenate, much smaller than the first two.

This terminates the first season's growth.

Betula alba, *L.* (fig. 672).

Hypocotyl erect, terete, pale green, densely pubescent, 8 mm. above the soil.

Cotyledons small, oblong-ovate, obtuse, petiolate; lamina glabrous, 3–4 mm. long, 2·5–3 mm. wide; petiole grooved above, rounded and pubescent on the back, 1·5 mm. long.

Stem woody, erect, terete, pubescent at the base, hairy upwards, ultimately with the bark peeling off longitudinally in stripes leaving the trunk white; 1st internode 4 mm. long; 2nd 6 mm.; 3rd 4 mm.; 4th 7 mm.; 5th 9·5 mm.

Leaves simple, cauline, alternate, stipulate, petiolate, alternately penninerved, glandular on both surfaces and hairy when in the young or seedling stage, ultimately glabrous and dotted with sessile glands on both surfaces, deep green above, pale beneath; petioles subterete, channelled above, densely pubescent in the seedling stage, glabrous in adult specimens after full development, slightly twisted so as to bring the surface of the leaf up to the light in pendent branches; stipules small, ovate or triangular, ciliate, caducous.

No. 1. Small, ovate, trifid, three- or obscurely five-nerved.

No. 2. Ovate, obtuse, serrate, five-nerved at the base, alternately penninerved upwards.

No. 3. Triangular, coarsely serrate.

No. 4. Triangular-ovate, coarsely serrate.

No. 5. Triangular-ovate, coarsely almost doubly serrate, subcuneate at the base.

No. 6. Cordate, acute, lobulate-serrate or doubly serrate.

Ultimate leaves ovate, acuminate, doubly serrate, subcuneate at the base, glabrous, glandular on both surfaces, fragrant.

SALICINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 411.

Fruit and Seed.—The ovary is superior, and one-celled with two to four parietal placentas. The ovules are numerous, inserted in two or many series on the placentas below the middle of the ovary, ascending and anatropous. The fruit is capsular, and ovoid or oblong, dehiscing by two or four valves according to the number of carpels of which it is composed. The seeds are numerous, small or minute, furnished with a dense coma of long, silky hairs arising from the funicle, and exalbuminous. The embryo is straight and conforms to the interior of the seed with oblong plano-convex cotyledons, and a very short inferior radicle.

Seedlings.—The cotyledons of Salix repens (fig. 673) are oblong-oval, petiolate, very small and show a midrib but indistinctly. The first leaf is lanceolate, subacute, entire, rounded at the base, one-nerved and exstipulate. Seeds sown in a greenhouse germinated in the remarkably short space of two days. The cotyledons of S. cinerea do not differ in any appreciable degree from those of its congener. The two primary leaves are ovate, entire, or show a small tooth on each side. The third one is oval, acute, and tapers to the base. The ultimate leaves vary between oblong, elliptic, and obovate. The seedlings were self-sown.

Salix repens, *L.* (fig. 673).

Hypocotyl erect or ascending, terete, glabrous, pale green or reddish, 2·5–3 mm. long.

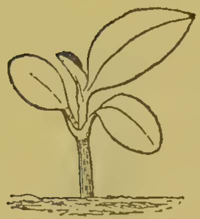

FIG. 673.
Salix repens, × 3.

Cotyledons oblong-oval, obtuse, entire, petiolate, with an indistinct midrib, glabrous, light shining green; lamina 2·5–2·75 mm. long, 1·5–2 mm. wide; petiole semiterete, flattened above, thickened at its insertion on the stem, 1 mm. long.

Stem in the early seedling stage erect, terete, pale green, glabrous, ultimately decumbent or creeping, much branched, woody.

Leaves simple, cauline, alternate, exstipulate or stipulate, petiolate, alternately incurvinerved.

No. 1. Lanceolate, subacute, entire, rounded at the base, shortly petiolate, exstipulate, with a distinct midrib but no other discernible venation in the young state when fresh, deep shining green above, glaucous beneath, glabrous; petiole grooved above, convex on the back, short.

Salix cinerea, *L.*

Hypocotyl a deep purple, 5 mm. long.

Cotyledons very similar to those of S. repens.

Stem shrubby, erect, terete, pubescent, deep purple; 1st internode 1·5 mm. long; 2nd and 3rd very short or undeveloped.

Leaves simple, cauline, alternate, stipulate, petiolate, greyish, pubescent above, densely so or tomentose beneath, alternately incurvinerved and reticulate, but most distinctly so beneath; petioles short, dilated at the base, somewhat channelled above, pubescent, brownish or purple; stipules small and rather variable, half reniform, revolute at the margin, pubescent or tomentose like the leaves, reticulate.

Nos. 1 and 2. Small, ovate, acute, entire or with a small tooth on each side.

No. 3. Tapering to the base, oval, acute.

Ultimate leaves variable, oblong-elliptic, or subobovate, or oblong-lanceolate, obtuse at the apex, or very shortly cuspidate, subundulate and revolute at the margin, the latter at least when dry, entire or distantly serrulate.

GNETACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 417.

Fruit and Seed.—There is no ovary in this Order, and the naked ovule has a double or triple coat, the outer one of which is fleshy or thin and fibrous and the innermost membranous and produced into a long, slender tube above the nucellus, exserted from the mouth of the outer coat and simulating a style. The nucellus is ovoid or conical, solid or nearly so before fertilisation, but after that less solid. The seed is drupaceous or membranous and compressed, erect, and contains a thin or moderately thick layer of endosperm. The embryo is straight with the cotyledons longer or shorter than the radicle.

One type of the Order is represented by Ephedra altissima (fig. 675). The fruit consists of an ovoid or conical seed enclosed in a tubular, red cup consisting of two connate bracts, free at the tips and leaving an opening between them beyond which the seed projects. At the base of this cup externally are two much shorter and decussating pairs of connate bracts. The outer coat of the seed is crustaceous and the inner membranous. The embryo is as long as the endosperm and has two linear-oblong, plano-convex cotyledons about twice the length of the superior radicle.

Seedlings.—The seedlings of three or four species of Ephedra coming under my observation are very similar, the chief differences consisting in the length of the cotyledons and the primary leaves. During the germination of Ephedra altissima the testa splits longitudinally and may or may not be carried up by the cotyledons as they rise above ground and straighten. The cupular process observed lying over the tip of the radicle in the seed seems designed to fix the latter in the ground during germination while the cotyledons rise up free. It is then seen to form a tubular sheath surrounding the base of the radicle and attached to the empty testa which is by that means pinned to the ground. Sometimes the attachment becomes broken and the testa is carried up on the tips of the cotyledons where it sometimes remains for a considerable time. The cotyledons are linear, emarginate, plano-convex, erect, but often much undulated or twisted by unequal growth or by their efforts to get out of the seed, slightly connate at the base, 3·1–5·7 cm. long and 1·5–2·25 mm. wide. The primary leaves are opposite, decussate, connate at the base, and the first four pairs are often unequal in length and vary from subulate to linear, similar to, but much shorter than the cotyledons. The cotyledons of E. fragilis differ but slightly from those of E. altissima, the chief distinctions being that they are acute, straight and 5–7 cm. long. The first node of the stem above the cotyledons bears three leaves in a whorl.

The cotyledons of Ephedra vulgaris (fig. 674) are linear, slightly channelled above, 3·1 cm. long and 1 mm. wide. The leaves are opposite and decussate, ovate, obtuse, connate at the base, very small and scale-like, and being so from the first pair onwards, they offer a marked contrast to those of E. altissima. The stem has a jointed appearance like that of Casuarina or Equisetum. The cotyledons of an unnamed species of Ephedra from Afghanistan are linear, semiterete, obtuse, grooved on the upper surface, slightly connate at the base, and otherwise closely resemble those of E. vulgaris.

Ephedra vulgaris, *Rich.* (fig. 674).

Hypocotyl tapering downwards into the radicle, brown when old.

Cotyledons two, linear, obtuse, slightly channelled above, glabrous, glaucous-green, 3·1 cm. long, about 1 mm. wide.

Stem shrubby, diffuse, terete, striate, finely scabrous on the ridges, glabrous, deep green; 1st internode 9–13 mm. long; 2nd 1·3–1·5 cm.; 3rd 1·8–2·2 cm.

Leaves very small, cauline, opposite, decussate, sessile, ovate, obtuse, connate at the base, convex on the back, glabrous, pale green, thick and subfleshy when young, and entirely enclosing the growing tip in bud, becoming pale or brown and scarious at an early age, persistent, ultimately torn by developing axillary buds.

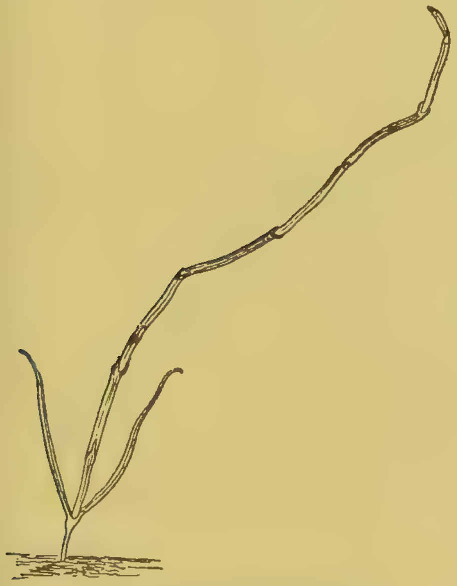

FIG. 674.—*Ephedra vulgaris*. Two-thirds nat. size.

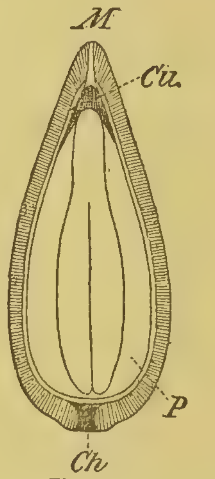

FIG. 675.
Ephedra altissima, × 5.
Longitudinal section of seed through the cotyledons: *M*, micropyle; *Cu*, cupular process of loose tissue; *P*, endosperm; *Ch*, chalaza.

Ephedra altissima, *Desf.* (fig. 675).

Ovule enclosed in a tubular, shortly bifid, glabrous, pale red envelope, and that again in two successively smaller envelopes, erect, terminal, orthotropous; micropyle superior.

Seed enclosed in the tubular processes above-mentioned, each of which consists of a pair of connate, opposite, decussate bracts. Sometimes there is present the remains of a second aborted ovule. Narrowly and pointedly ovoid-conical, glabrous, brown, obsoletely four-ribbed towards the apex; testa thick, crustaceous and tough; tegmen very thin, membranous, brown, more or less exserted as a styliform process when in a young state; hilum and chalaza basal; micropyle apical.

Endosperm copious, fleshy, white, embedding the embryo, except at the tip of the radicle, and forming only a very thin layer round the apex of the cotyledons.

Embryo straight, nearly as long as the cavity of the seed, comparatively large, lying in the axis of the endosperm; cotyledons two, oblong-linear, obtuse, entire, fleshy or thick, plano-convex, closely applied face to face in the seed, about twice as long as the radicle; radicle stout, oblong, terete, very obtuse, slightly constricted in the middle with the upper half white like the cotyledons and the lower half yellow, lying in a cup-like process of loose tissue close to the micropyle.

Ephedra fragilis, *Desf.*

Hypocotyl as in E. altissima, 1–2·5 mm. long.

Cotyledons linear or acicular, fleshy, 5–7 cm. long, glabrous, acute, green.

Stem erect, terete, herbaceous, ultimately woody; 1st internode 1–1·5 mm. long.

First leaves three in a whorl, simple, entire, cauline, linear, acute, glabrous.

An undetermined species of Ephedra, from Afghanistan, has very similar cotyledons.

Seedling.

Primary root long, tapering downwards, copiously furnished with root-hairs, without lateral rootlets till it attains some size, tipped in the seed by a cup-like process which forms a sheath to it after germination.

Hypocotyl erect, terete, glabrous, green, 3·5–12·5 mm. above the soil, stout, and fleshy at first.

Cotyledons long, linear, emarginate during or after germination, and generally more or less discoloured at the tip, semiterete, flat above or slightly grooved, rounded on the back, deep green and often distinctly glaucous, glabrous, often twisted or variously bent in making their escape from the seed, connate at the base and forming a cupule round the plumule, not differentiated into lamina and petiole, erect with spreading tips for a long time at least after completing germination, 3·1–5·7 cm. long, 1·5–2·25 mm. wide.

CONIFERÆ.

Benth. et Hook. *Gen. Pl.* iii. 420.

Fruit and Seed.—The ovules are naked, solitary, or vary from two to several collaterally inserted near the base, rarely under the apex of an ovuliferous scale in the axil of a bract; they are superficial or partly submersed in the tissue of the scale and erect or reversed with the micropyle superior or pointing to the base of the scale accordingly. The fruit is usually a cone consisting of closely imbricating scales covering the seeds; but in many species of the tribes Taxeæ and Podocarpeæ, and in Cephalotaxus the scales remain small while the large, solitary seed projects considerably beyond them. The seed is ovoid or oblong with a membranous, fleshy or crustaceous testa sometimes winged at the sides or again at the apex. Endosperm is copious and fleshy or farinaceous, and remarkably ruminated in Torreya. The embryo is straight and axial with two, three or many cotyledons, usually shorter than the radicle.

Pinus Pinaster may serve as a type of the Order. The seeds are winged at the upper end, the wing being produced by delamination from the inner layer of the ovuliferous scale. The outer layer of the testa is thick and woody while the inner one is membranous. The embryo is clavate, and straight, with six to seven or more cotyledons which are trigonous, obtuse and several times shorter than the cylindrical radicle.

Seedlings.—The cotyledons vary greatly in different genera, and in the different species of Pinus, Abies, and Picea the number varies even in individuals. They also vary more or less in shape dependent upon their number, in the same way as in the secondary leaves of Pinus. When there are only two they are flat or plano-convex, but when more numerous they are trigonous, triquetrous, or form some segment of a cylinder.

The cotyledons of Taxus baccata (fig. 677) are linear, obtuse, flat, or slightly plano-convex, two in number, 1·7 cm. long, and 2 mm. wide. The primary leaves are opposite or nearly so, spreading, decussate, and nearly flat. The first pair are lanceolate-linear and acute; the next two pairs are linear and subacute; while the fourth and fifth pairs are linear, cuspidate, and unequal in size, as if really alternate and scattered, and such in fact may be the case. The leaves of lateral branches in the seedling resemble those of the adult in being scattered with a distichous arrangement, while the phyllotaxy remains the same. On ascending or upright shoots they ascend in various directions, and are not bifariously arranged. All have a distinct midrib seen on both surfaces, but more prominent on the upper, are distinctly petiolate, and arise from a linear-oblong, elevated pulvinus or process adnate to the shoot.

The cotyledons of Thuya occidentalis are linear, acute, tapered to the base, one-nerved, flat or nearly so, and two in number. The two first leaves are opposite, spreading, similar to, but smaller than the cotyledons, and are followed by five or more whorls of three similar ones. In some cases one of the three is inserted at a slightly higher level than the rest, or they may even all be scattered with a spiral arrangement. The ultimate leaves are opposite, decussate, and adnate for great part of their length to dorso-ventrally flattened shoots. The cotyledons of Thuya gigantea (fig. 676) conform to the above type. The first four leaves are in opposite pairs decussating with the cotyledons, and are followed by a number of whorls or pseudo-whorls, of similar but longer and more decidedly acicular leaves. Above the first dozen or so of whorls, lateral branches are given off bearing sometimes a few acicular and spreading leaves at their bases, while succeeding leaves are imbricate and decurrent, gradually giving place to closely imbricate and decurrent leaves, arranged in four rows and decussate. The branches are then horizontal or drooping, and dorso-ventrally flattened.

Cryptomeria japonica differs from the above-mentioned species in having two to three linear, obtuse cotyledons flat above and slightly convex beneath. Out of fifteen seedlings examined, twelve had three cotyledons. The testa is very frequently carried up on the tips of the cotyledons during germination, but is ultimately thrown off by their bulging or bending out. It opens at the apex only to allow of the exit of the embryo.

The second well-defined type of cotyledons is met with in Pinus rigida (fig. 678). Here they are acicular, obtusely trigonous, acute and slender at the tips, four to six in number, and ultimately attain a length of 1·4–1·6 cm. They carry up the testa during germination, and push themselves out at an apical opening, first by the mere process of elongation, but afterwards get rid of the testa in the same way as Cryptomeria japonica. The primary leaves of the seedling are acicular, densely and spirally arranged on the axis. The primary ones of the adult are reduced to brown scales, while the secondary are arranged in fascicles of three in their axils, and are three to four inches long. The cotyledons of Pinus sylvestris vary from five to ten in number, and are acicular, serrulate at the margins, variously angled and compressed. Those of Pinus halepensis prolifera are acicular, trigonous, acute, 3–4 cm. long, and vary in number from seven to nine. Picea orientalis agrees very closely with Pinus and has six to ten acicular, attenuate cotyledons, obtusely trigonous and distantly ciliate-serrulate at the margins. They make their exit from the testa in the same way as in Pinus rigida, and when full grown radiate horizontally with their tips curved in one or two directions. When about half-grown and still surmounted by the testa they curve outwards regularly in the form of a balloon. The crustaceous testa splits longitudinally, but the surrounding endosperm remains intact except at the point of exit at the micropyle, forming a sheath to the cotyledons.

Actinostrobus pyramidalis may be placed here, as although it has only three cotyledons, they are linear-subulate, subtriquetrous, and 9 mm. long. The primary leaves are similar to the cotyledons in outline, and verticillate in whorls of three, but are biconvex, decurrent upon the axis, and cover the whole of the internodes with the free portion 8–13·5 mm. long.

Actinostrobus pyramidalis, *Miq.*

Hypocotyl woody, erect, terete, glabrous, brownish, about 7–10 mm. above the soil.

Cotyledons three, linear-subulate, acute, subtriquetrous, glabrous, glaucous-green, spreading or arching, with the broadest face towards the soil, and one on each side of the median ridge on the upper surface, 9 mm. long.

Stem woody, erect, glabrous, glaucous, obtusely three-ridged and shallowly three-furrowed owing to the adherent or decurrent bases of the leaves; 1st internode undeveloped; 2nd 5 mm. long; 3rd 4·25 mm.; 4th 5·25 mm.; 5th 6 mm.; 6th 5 mm.; 7th 6 mm.; 8th 5·5 mm.; 9th 4 mm.

The primary leaves are simple, entire, cauline, verticillate in whorls of three, linear-subulate, acute, horizontal, compressed horizontally, and convex on both surfaces, decurrent or adnate by their faces to the stem, and covering the whole internodes with the free part, 8–13·5 mm. long, deep glaucous-green above and paler beneath.

Thuja gigantea, *Nutt.* (fig. 676).

Primary root long, woody, flexuose, brown, with a few long brownish fibres.

Hypocotyl woody, erect or suberect, terete, about 1·5 cm. long, 1·5 mm. thick, brown.

Cotyledons two.

Stem woody, terete and smooth near the base, ridged higher up from the decurrent sessile leaves, brownish-green.

Leaves of two kinds, with intermediate stages.

(*a*) Acicular leaves in more or less true whorls, decurrent except the few lowest, which are only 2–3 mm. long by ·75 mm. wide, and yellowish-green, whilst the upper ones are 1 cm. long, 1·5 mm. wide, prominently decurrent, sharply pointed, and dull dark green above with a lighter tint and white midrib on the lower surface.

After about a dozen pseudo-whorls, the first branch is formed and may or may not bear a few acicular leaves, passing gradually or suddenly into the second predominating form.

(*b*) Scale-like, imbricate leaves as in Thujopsis dolabrata, &c.[1]

Thuja occidentalis,[2] *L.*

Primary root tapering downwards with a few fibrous lateral rootlets.

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[1] Tubeuf, l. c. p. 103, figures and describes the same species and says of the cotyledons, 'about 6 mm. long, and 1–1·5 mm. wide, broadly pointed, green on both surfaces, midrib scarcely visible.' He also (p. 102) figures and describes Thuja japonica, which differs from T. gigantea in having broader cotyledons, and the primary leaves in opposite decussate pairs. The seeds of these two species are also described (p. 31).

[2] Cf. Tubeuf, l. c. p. 101 (with figure of a very young seedling). The cotyledons are described as about 8 mm. long, by 1 mm. wide.

Hypocotyl erect, quadrangular, glabrous, 5 mm. long, light green.

Cotyledons two, linear, acute, entire, sessile, slightly tapering towards the base, glabrous, light green, one-nerved.

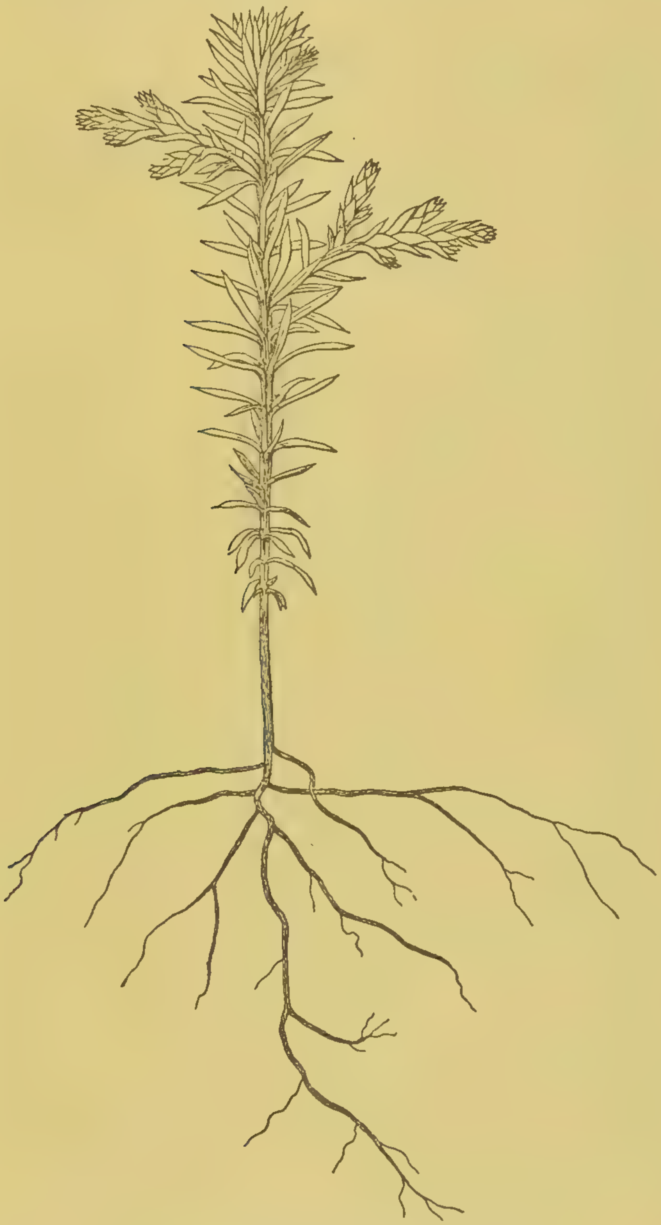

Fig. 676.—*Thuja gigantea.* Nat. size.

Stem ascending, herbaceous, ultimately woody, quadrangular, light green; 1st internode very short; 2nd and following ones considerably longer.

Leaves cauline, opposite and verticillate, arranged in whorls of three, though in some plants they seem to be in pairs with the odd one slightly higher, or have even a spiral arrangement, linear, acute, sessile, exstipulate, glabrous, light green, one-nerved.[1]

In all the Junipers and Thujas the young plants have needle leaves. In many species of the Cupressineæ the subsequent foliage is flattened; and in some the two tendencies are so nearly balanced that even on the same branch some twigs bear acicular, some flattened, leaves. The former seem to be especially developed on the lower and inner branches.

Cryptomeria japonica, *Don.*

Primary root tapering downwards, somewhat flexuose, pointed, colourless, unbranched in its early stage.

Hypocotyl erect, terete, glabrous, pale green, slightly stained with red at the base, 1–1·6 cm. above the soil.

Cotyledons two to three, linear, obtuse, flat above and deep glaucous-green, slightly convex beneath and paler, 6·5–8 mm. long, 1·5–2 mm. wide. Out of seventeen seedlings three had two cotyledons, twelve had three cotyledons, and two were not sufficiently advanced to determine the number.

Stem erect, ultimately woody; primary internodes undeveloped; ultimate ones very short.

Leaves simple, entire, cauline, spirally arranged on the stem and close together, exstipulate, sessile, decurrent, linear-falcate, ascending towards the apex of the branches, three- to four-angled with the posterior or dorsal angle strongest and decurrent on the stem or branch, glabrous, deep glaucous-green.

Nos. 1–3. Following each other closely, often appearing verticillate and alternating with the cotyledons.[2]

Taxus baccata, *L.* (fig. 677).

Primary root tapering, fleshy, colourless, giving off very few lateral fibres in its early stages.

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[1] Tubeuf, l. c. p. 103, describes and figures (fig. 143), the seedling of Thujopsis dolabrata, which resembles that of Thuja gigantea, but has broader, very blunt cotyledons. The primary leaves are also shorter and broader.

Biota orientalis, l. c. p. 104 (fig. 144), has two much larger cotyledons, 2·2–2·5 cm. long, 1·5–2 mm. wide, but is otherwise at first very similar.

[2] *Vide* Tubeuf, l. c. p. 97, where is a figure of a seedling and also of a two-year-old plant. The seeds are described on p. 32.

Hypocotyl erect, terete, glabrous, green, finely striate, soon becoming woody, 2·8–3·9 cm. long.

Cotyledons two, linear, obtuse, glabrous, 1·7 cm. long, 2 mm. wide.

Stem erect, suffrutescent and soon becoming woody, subangular, glabrous, green; 1st internode 2 mm. long; 2nd 3 mm.; 3rd 1·5 mm.; 4th ·5 mm.

Leaves simple, entire, cauline, exstipulate, sessile, opposite in the seedling state, but the pairs at the growing point develop unequally, as if alternate, glabrous, persistent, deep green above, paler beneath, with a prominent midrib on both faces.

First pair lanceolate-linear, attenuate, acute, 1·7 cm. long.

Second and third pairs linear, subacute.

Fourth pair linear, cuspidate.

Fifth pair linear, cuspidate, very unequal in size, the shorter one not half the length of the other, at least while young and still growing.

Ultimate leaves alternate or scattered, arranged distichously in a double row on each side of the branches with the upper faces all turned in one direction, and articulated with a linear-oblong, cushion-like piece, adnate to the branches; upper series of leaves shorter than, and alternating with the series beneath it; leaves linear, straight or falcate, acute or cuspidately acute, persistent, deep green above, paler beneath, especially when young, with a prominent midrib on both surfaces, and a very pale line on each side of the midrib beneath.

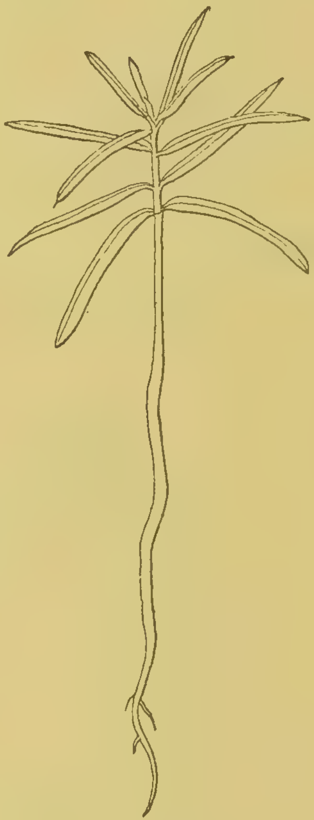

FIG. 677.—*Taxus baccata.* Nat. size.

Pinus Pinaster, *Soland.*

Ovary consisting of an open carpel on the base of the inner face of which two ovules are seated on a process termed an ovuliferous scale; ovules reversed, adnate to the scale in the early part of the season; micropyle inferior.

Fruit a cone consisting of scales spirally arranged in many series. The carpellary scales do not increase after fertilisation, remaining small, and membranous; but the inner seminiferous scales become large and woody, thickened at the end, densely imbricating and each containing at the base of the inner face two large winged seeds resembling samaras. Scales persistent, ultimately separating to allow the seeds to drop out.

Seed obovoid, dorso-ventrally compressed and winged at the top; after removal of this wing the margins are seen to be drawn out into two thin edges, or incipient wings; seed-coat after removal of the wing consisting of two layers, the outer one of which is thick, hard, and woody, comprising a thin outer dark brown or black stratum, and a pale brown, much thicker inner stratum; the inner layer is pale brown and black at the radical end of the seed, thin and membranous, but capable of being broken or split up into two thinner strata; micropyle inferior; chalaza superior.

Endosperm copious, white, subfarinaceous, surrounding the embryo.

Embryo central, large, straight, nearly equal in length to the endosperm, colourless; cotyledons six to seven, packed together in a clavate mass, linear-oblong, obtuse, trigonous, several times shorter than the radicle; radicle and hypocotyl together stout, cylindrical, abutting against the remains of the suspensors at the base of the seed and close to the micropyle.

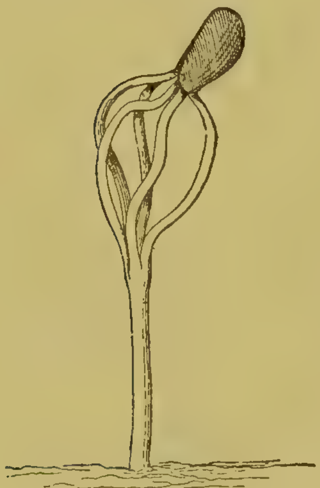

FIG. 678.—*Pinus rigida*, × 2.

Pinus rigida, *Mill.* (fig. 678).

Primary root tapering downwards, subflexuose, unbranched for some time after germination.

Hypocotyl erect, terete, glabrous, deep glaucous-green, and more or less stained with red near the base, 8–18 mm. above the soil.

Cotyledons four to six, acicular, obtusely trigonous, attenuately acute and slender at the tip, glaucous-green, glabrous, straight in the seed, but during germination pushed out by their own elongation, bulging out all round, and finally pulling themselves out of the seed, after which they gradually spread out to the light, attaining a length of 1·4–1·6 cm.[1]

Stem erect, woody.

Leaves dimorphic, simple, cauline, sessile, exstipulate, glabrous.

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[1] Tubeuf, l. c. p. 86, says: 'The plant has lost its cotyledons by the beginning of the second year.'

Primary ones small, scale-like, hyaline, spirally arranged in many series, more or less deciduous.

Secondary ones acicular, acute, fascicled in clusters of three in the axils of the primary scarious leaves, evergreen, and persisting several years.

The first leaves of the seedling are numerous, alternate, densely and spirally arranged, plano-convex and acicular.

Pinus sylvestris, *L.*

Primary root long, tapering but slightly, rather fleshy, subflexuose, unbranched in the early stage.

Hypocotyl glabrous, pale green, about 4·4 cm. long.

Cotyledons ten (in specimen described), whorled, ascending, acicular, acute, distantly serrulate at the margins, semiterete and flattened above or variously compressed, and angled by mutual pressure, deep subglaucous-green, forming a vasiform cupule around the plumule.[1]

Pinus halepensis, *Mill., var.* prolifera.

Hypocotyl covered with a fine bloom, purplish-green, 3–4 cm. long.

Cotyledons seven to nine, acicular, trigonous, 3–4 cm. long, acute, covered with a fine bloom, glaucous-green.[2]

Picea orientalis, *Carr.*

Primary root tapering downwards, and some time after germination very much elongated, flexuose with a few very short scattered lateral rootlets.

Hypocotyl erect, terete, glabrous, striate or shallowly ridged and furrowed, the furrows opposite to or running down from the back of the cotyledons, and the ridges corresponding to their united and decurrent edges, 1·8–3·2 cm. long, slender, pale green or ultimately straw-coloured, slightly twisted.

Cotyledons six to ten, acicular, attenuately acute at the tip, obtusely trigonous, distantly and minutely ciliate-serrulate, deep subglaucous-green, straight in the seed, emerging as in Pinus, finally radiate and straight, or more or less twisted or curved in one or two directions, 1·1–1·7 cm. long.

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[1] Cf. Tubeuf, l. c. p. 83, fig. 110; the cotyledons are described as mostly six in number (4–7), to 2 cm. long, with two resin canals, and the primary leaves as serrate on both edges, and spiral with no resin canal. The cotyledons die in the winter and hang on the plant till spring.

[2] Tubeuf, l. c. pp. 82–88, describes also P. montana, fig. 111 (very like P. sylvestris); P. Laricio, fig. 112 (cotyledons 6–8); P. Thunbergii (cotyledons 6–8); P. Pinaster, fig. 113 (cotyledons 7–9); P. Pinea, fig. 114 (cotyledons 10–13, about 6 cm. long); P. ponderosa, fig. 115 (cotyledons 9); P. Jeffreyi (cotyledons 10, up to 5 cm. long); P. Cembra, fig. 116 (cotyledons 9–12); P. Strobus, fig. 117 (cotyledons 8–11); P. excelsa, fig. 118 (cotyledons 9–11).

Plumule covered with a cap of scales the outer of which are pale brown, the inner smaller, more numerous and hyaline.

Stem erect, ultimately woody.

Leaves simple, entire, cauline, acicular, spirally scattered, obtusely tetragonous, narrowed at the base into a very short petiole and jointed to a little pulvinus on the branches, deep green, very short.[1]

CYCADACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 443.

Fruit and Seed.—The male and female flowers are arranged in separate cones in most genera; those bearing the ovules are generally the thicker. The scales are closely imbricated and spirally arranged; in the case of Cycas they are greatly elongated and bear the ovules alternately on the lateral margins. They, in fact, resemble aborted leaves densely covered with rusty brown hairs. In other genera the scales are very short, much thickened, peltate and bear a single orthotropous ovule on each side pointing towards the axis. The testa is single and produced into a short tube at the micropyle. The seed is large, variable in shape, and often variously angled. The outer layer of the testa is orange or red, and the inner crustaceous or bony. Endosperm is copious and fleshy, embedding the subcylindrical embryo in its upper part; and the cotyledons are conferruminate or amalgamated in one piece, or free at the base only to permit the exit of the plumule.

Seedlings.—As the seeds are large in nearly all the genera of the Order and differ in this respect from the Gnetaceæ and Coniferæ, so I find that in all the seedlings observed the cotyledons are subterranean, and remain in the seed till the endosperm is absorbed, when they decay. Another peculiarity is that the plumule consists of a mass of stout, fleshy scales resembling a resting or winter bud, which emerges from the fissure at the base of the cotyledons during germination. A solitary perfect leaf is soon after developed from the centre of the bud as seen in Zamia integrifolia. This leaf consists of two pairs of leaflets, crowded together at the apex of the petiole; the terminal pair is much the smaller, and all have numerous, longitudinal, parallel nerves.

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[1] Tubeuf, l. c. pp. 90–92, describes seedlings of Picea excelsa, fig. 121; P. alba, fig. 122; P. polita, P. orientalis, fig. 123; P. Alcockiana, fig. 124; P. Omorica, P. sitchensis, fig. 126; all of which bear a general resemblance to that of P. orientalis.

The seed of Cycas Beddomei (fig. 679) is globose-oblong, and the bud formed by the plumule is rather small, consisting of one or two scales. The method of germination corresponds to that of Zamia integrifolia. The primary perfect leaf is pinnate with eleven to nineteen linear, entire leaflets having a distinct midrib only. Dioon spinulosum has a comparatively large, oblong seed and a large bud of four scales. The first leaf is finely pec-

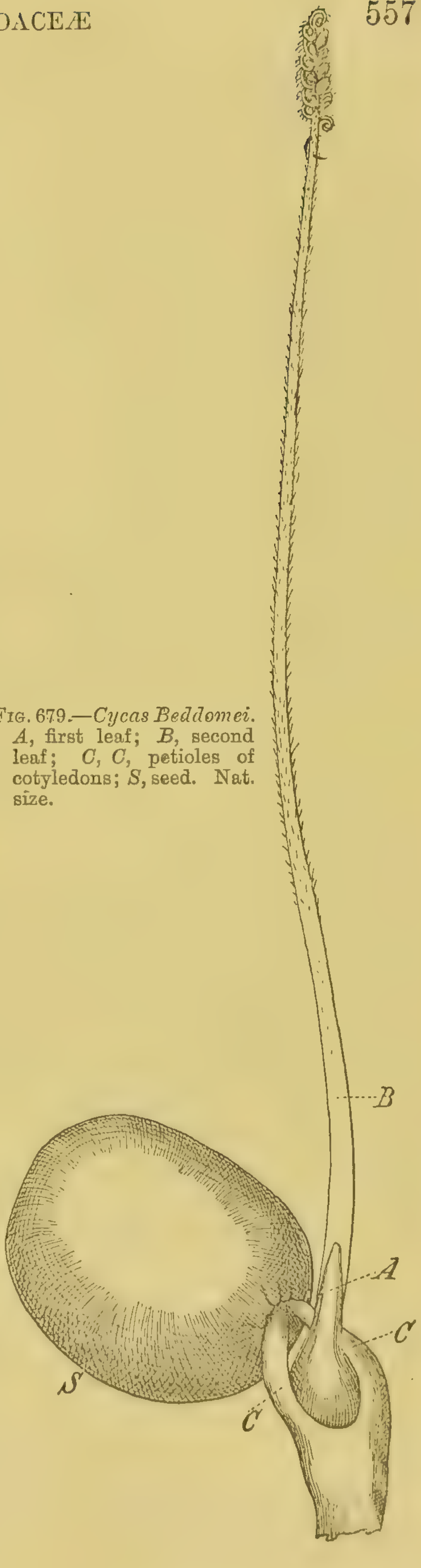

FIG. 679.—*Cycas Beddomei.* *A*, first leaf; *B*, second leaf; *C*, *C*, petioles of cotyledons; *S*, seed. Nat. size.

tinate or pinnate with twenty-three to twenty-five spiny-serrate leaflets, the veins of which are longitudinal, slender, and numerous. In all three cases the leaflets are circinate in vernation like most Ferns.

Cycas Beddomei, *Dyer* (fig. 679).

Primary root very long, stout, fleshy, colourless, giving off a few short lateral rootlets after a time.

Hypocotyl very short, stout, subterranean, passing somewhat abruptly into the root.

Cotyledons two, subterranean, and remaining in the seed till they decay, petiolate; petioles stout, fleshy, semiterete, sufficiently long to allow the plumule to make its exit between them during germination.

Stem short, erect, woody, and of very slow growth, undeveloped for some considerable time after germination.

Leaves radical, ultimately all cauline, pinnate, alternate, exstipulate, petiolate, pilose when young particularly on the midrib beneath, evergreen, subcoriaceous; pinnæ linear, acute, entire with a distinct midrib but no other visible venation, circinate in vernation; petiole downy when young, ultimately glabrous, terete. First leaf, and sometimes the second, or even the third reduced to a large, subulate, semiterete, fleshy scale, without leaflets. Second leaf usually foliaceous with eleven to nineteen linear, entire leaflets.

Zamia integrifolia, *Ait.*

Cotyledons two, remaining in the seed, subterranean.

Stem erect, ultimately woody, of slow growth, and consequently short; internodes undeveloped.

Leaves cæspitose, pinnate; leaflets notched at the apex, sessile, almost linear but rather tapering towards the base, light green at first then dark green, glabrous, with parallel veins.

Primary leaves reduced to short scales closely investing the plumule, and owing to the undeveloped condition of the internodes resembling a resting or winter bud. First true leaf with two pairs of linear-spathulate, somewhat oblique leaflets; petiole thinly hairy, green, soon becoming brown.

HYDROCHARIDEÆ.[1]

Benth. et Hook. *Gen. Pl.* iii. 448.

Fruit and Seed.—The ovary is inferior, one-celled, with three to six placentas, rarely fewer or more, parietal or projecting into the centre of the cavity without uniting; ovules several on each placenta, pendulous or, especially the lower ones, ascending, anatropous or sometimes orthotropous. The fruit is submerged, globose, ovoid, oblong or linear, dry or more or less pulpy, bursting irregularly through swelling of the jelly-like contents, or opening by decay of the pericarp; one- or six- to many-celled by coalescence of the placentas in the centre; pericarp membranous or rarely somewhat fleshy. The seeds are numerous, oblong; the outer layer of the seed-coat consists of spirally thickened cells, swelling up and becoming mucilaginous in water; the inner layer is usually hard and more or less crustaceous, as in Stratiotes, and especially in Blyxa, where it is sculptured and almost bony. In some species, as B. echinosperma, the testa has thorny prolongations. The seeds are small in the Vallisnerieæ, Blyxa and the Ottelieæ, larger in the other tribes. They are exalbuminous, the embryo completely filling the seed.

In the freshwater genera the hypocotyl coheres with the cotyledon into a more or less oval mass, including the small plumule at the base of a lateral cleft. As examples, compare Lagarosiphon muscoides, figured by Caspary,[2] who says 'the embryo has a very strong resemblance to that of Naias major, minor, and flexilis, and gives an indication of the systematic position of the Hydrilleæ.' Vallisneria, Ottelia, and Hydrocharis also follow this type. The embryo terminates in a small radicle.

Stratiotes is exceptional among the freshwater genera. Here[3] the cotyledon is distinct from the hypocotyl, linear-lanceolate in outline, and only slightly sheathes the plumule with its edges at the base. The plumule is large and exceptionally well developed, including eight to ten young foliage leaves, of which the outer ones sometimes reach to the apex of the cotyledon. The fleshy conical hypocotyl is about a quarter the length of the cotyledon, and there is no trace of any radicle.

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[1] In this and some of the following Orders I have no observations to record. It may still, however, be convenient, for purposes of reference, to give a short description of the fruit and seed.

[2] Die Hydrillen, in *Pringsh. Jahrb.* i. 478.

[3] Irmisch, *Flora*, 1865, p. 81, t. 1.

In Halophila and Thalassia, which inhabit the sea, the embryo consists of a strongly developed lower hypocotyledonary, or hypocotyledonary and radicular portion bearing a very distinct but much smaller cotyledon which sheathes the plumule. In Halophila[1] the lower part consists entirely of hypocotyl, the radicle being absent as in Stratiotes. In Thalassia Hemprichii we find according to Solms[2] an 'extraordinarily large stem and root portion' filling the whole under part of the seed, in the apex of which is the small cotyledon and strongly developed plumule. Embryos such as these are termed macropodous (large-footed).

Stratiotes aloides,[3] *L.*

Fruit a capsule, six-celled, unequally angled, mucous.

Seeds anatropous, in the angle of the thick outer and the thin inner wall, almost erect; raphe towards the centre of the fruit; micropyle and hilum contiguous and directed towards the outside wall. Rather long, slightly verrucose, and with a slight carina; testa hard; tegmen very thin.

Endosperm absent.

Embryo unusually far developed, including eight to ten young foliage-leaves spirally arranged, forming the plumule; cotyledon linear-lanceolate, thick, fleshy, only very slightly embracing the plumule with its edges at the base, its apex rounded or pointed and the outer leaves of the plumule sometimes reaching the apex, sometimes shorter; in its axil and also in that of the outer foliage-leaves are two small scales (squamulæ intra-axillares); hypocotyl fleshy and conical, about one-fourth the length of the cotyledon and bearing at the end a particle of dead tissue, the remains of the suspensor; radicle absent. A longitudinal section of the hypocotyl shows the commencement of a lateral root beneath the growing point of the plumule.

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[1] J. B. Balfour, *Trans. Bot. Soc. Edinburgh*, xiii. (1879).

[2] Solms-Laubach, in *Schweinfurth, Flora Aeth.* p. 195.

[3] Cf. Klinsmann, *Bot. Zeit.* 1860, p. 81, taf. ii.; and Irmisch, *Flora*, 1865, p. 81, t. 1.

Germination.—The hard brittle seed-coat splits from the micropylar end upwards, but often remains for a time entire at the opposite end, seated on the tip of the cotyledon, but sooner or later the two halves fall apart. The delicate colourless tegmen remains inside the brown testa. The cotyledon quickly elongates, without any considerable increase in thickness, to three-quarters to one inch, it is semiterete, shallowly grooved above at the base, while the apex is thinner and usually bent upwards; colourless at first, but soon becoming green like the foliage-leaves. The hypocotyl is coloured like the cotyledon, and like it undergoes no striking change, merely elongating somewhat.

The leaves of the plumule soon bend downwards, and get longer and somewhat broader, their edges are separated at the base, and they are sessile; the apex is often spirally rolled; they are traversed by a stronger midrib and two to four lateral nerves, and their edges have small forwardly directed teeth, so that they agree essentially with the later foliage-leaves except in size. The intra-axillary scales are rather longer than in the case of the cotyledon.

The seedling lives at first on the nutriment stored in the cotyledon and hypocotyl; it is not for some weeks that the lateral root bores through the parenchyma on the side of the hypocotyl beneath the median line of the cotyledon. It is thread-like and unbranched.

Stem of the mature plant very short, stoloniferous.

Leaves radical, sessile, linear-lanceolate, acute, serrate with short, pungent, upwardly directed teeth, traversed by a midrib and two to four weaker parallel nerves on either side, green, glabrous, somewhat fleshy.

A submerged perennial herb.

BURMANNIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 455.

Fruit and Seed.—The ovary is inferior, three-celled, with axile placentation, or one-celled with three parietal placentas. Ovules minute, anatropous, very numerous on each placenta. Fruit a capsule, crowned by the marcescent perianth, terete or three-angled or three-winged, membranous; dehiscing laterally between the ribs, or irregularly at the apex, or rarely by valves. Seeds very numerous, and very small, with a thin transparent testa, sometimes adnate to the nucleus, sometimes loose, hyaline and produced at both ends a long way beyond it. Recent researches [1] have shown that the seed, at any rate in many cases, contains something more than the rudimentary undifferentiated embryo which was formerly supposed to constitute the whole. Endosperm is present, and occupies the greater part of the seed, one of the cells being often very curiously developed. In Burmannia capitata according to Johow [2] a portion of the nucellus remains in the ripe seed (perisperm). In this species the number of the endosperm cells is very small (six in a longitudinal section), but they are each very large. At the apex lies, embedded in it, the undifferentiated embryo of ten cells. At the base is a small conical group of cells distinguished from the endosperm by their small size and dark colour; they are a remnant of the original nucellus and therefore perisperm. The endosperm cell at the extreme base of the embryo-sac is most curiously developed, the wall bordering on the perisperm having peculiar tap-like or coralline protuberances which penetrating the cell-contents reach almost to the opposite wall. This as well as the conical nucellar process (perisperm) may play some part in germination.

Apteria setacea is similar, but the differentiated endosperm-cell is hexagonal and appears symmetrically striated throughout, the protoplasm having apparently completely passed over into cellulose or a closely related substance; the perisperm is very small. The embryo, which agrees in all details with that of Burmannia javanica and Gonyanthes capitata as observed by Treub, is simpler than in B. capitata, containing only from three to six cells.

Burmanniaceæ is a small tropical Order of small herbaceous saprophytes containing about a dozen genera. Their germination does not seem to have been studied.

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[1] Treub, *Extrait des Annales de Jard. Buitenzorg*, iii. pp. 120-2.

[2] Johow, *Pringsh. Jahrb.* xvi. (1885), p. 415.

ORCHIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 460.

Fruit and Seed.—Ovary inferior, one-celled, with three parietal placentas, or three-celled in Selenipedium, Apostasia, and Neuwiedia, genera which are also markedly distinguished in other respects. Ovules anatropous, minute and very numerous. Fruit a membranous or coriaceous, cylindric, ovoid or winged capsule, rarely fleshy, and dehiscing scarcely at all or only after a time—some species of Galeola, Vanilla, and Sobralia, three allied genera—usually dehiscing by three or six longitudinal slits, with the valves cohering for some time or altogether at the apex or base, or finally spreading from the apex or entirely disappearing.

Seeds very numerous, minute, more or less cylindrical or spindle-shaped or tapering at one or both ends; testa thin-celled and transparent, yellow, green or brown, and very loosely enveloping the embryo. There is great variety in form, size, colour, and the configuration of the cells of the testa. Rarely is the testa winged, fitting close to the embryo from which it radiates in rows of delicate, transparent, brownish cells as in Epistephium, Erythrorchis, and Cyrtosia. Vanilla is also exceptional in having a crustaceous, dark reddish-brown, opaque testa. There is no endosperm. The embryo is in the centre or somewhat above the centre of the seed, globular, ellipsoid or ovate in shape, and represents a very low stage of development, showing before germination no trace of radicle or cotyledon. There is, however, a certain physiological differentiation, for the longer axis of the embryo corresponds to the ascending axis of the young seedling.

The seeds show a great resemblance to those of many parasites of dicotyledonous Orders, especially Orobanche, but most strikingly, as Beer points out, to those of species of Pyrola.

Germination.—Owing to the low stage of development of the embryo in the ripe seed, only trifling differences of form and colour occur in the most different genera and groups.

Angræcum maculatum,[1] *Lindl.*

Seed spindle-shaped with a thin transparent testa loosely enveloping the central pear-shaped homogeneous embryo.

Germination.—The embryo increases considerably in size and ruptures the testa from above downwards, the *débris* remaining attached at the lower end. At this stage *two* or *three* adventitious buds appear on the upper surface of the germ-tubercle; their position is very variable, and they are often all at a considerable distance from what we should imagine to be the position of the primary axis of the embryo; they all seem of the same nature, no one showing any peculiarity.

A rudimentary vascular bundle runs from the bases of the rudiments of the leaves of these buds down into the axis of the tubercle, the lower part of which, however, consists of undifferentiated cellular tissue.

The seedling is nourished by tufts of hairs which arise at numerous points of the surface of the rapidly growing top-shaped embryo. There is no trace of a primary root. The germ-tubercle has now completed its development, the future plant is produced from the adventitious buds. One of these develops more or less directly into the leaf- and flower-bearing axis, the others follow a uniform course of development and produce a branching system of tubers.

The young leaves of the bud are alternate and distichous as in the adult plant; they are reduced to minute deciduous scales, but their position can be readily ascertained by a linear scar marking their place of attachment. In the case of those which produce a secondary tubercle the bud increases considerably in bulk, the dilated axis bears distichously arranged leaf-scales in the axils of which appear buds which undergo a development similar to that of the axis on which they arose, thus producing a ramifying tuberous system. The other adventitious bud often develops for a time like its fellows, but sometimes immediately produces a leafy stem. In the former case this is developed in the axis of a leaf-scale of a secondary tubercle; in the latter the growing point of the adventitious bud itself develops into the leafy stem. The first two leaves are brownish membranous scales, the third and fourth are also scales but green, the fifth has a well-developed lamina and shows the form of a complete leaf. These primary leaves are all sheathing and at first enclosed one within the other, but they open out and extend with the growth of the axis which bears them.

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[1] Prillieux et Rivière, *Ann. Sci. Nat.* ser. iv. tom. v. (1856), p. 119, pl. 5–7.

Up to the time when the third leaf-sheath protrudes above the summit of the second, the plant has had no organ of absorption beyond the papillæ originally developed over the whole surface of the young tubercle. But now the rudiment of a true root appears on a level with the origin of the second leaf, inside the first sheath which it tears in elongating and then bends and penetrates the soil. While it is developing the third and fourth sheaths protrude; but before the complete leaf appears, the first sheath, torn by the root, has already begun to perish.

The leaves arise but a short distance apart, the internodes being very short. When the stem grows they elongate, but very unequally; the lowest always remains the shortest, the two next do not increase very much; but the last, at the summit of which is borne the fifth leaf, grows considerably, and finally overtops the summit of the sheaths at its base. It increases in breadth and thickness as well as length, and forms the pseudo-bulb; the narrow leaf-sheaths surrounding its base become torn and perish, while it bears at its summit the only leaf which attains complete development. During the growth of the pseudo-bulb a second and third adventitious root arise in succession from the base of the third and fourth sheaths respectively; they are like the first and penetrate the ground. Henceforth the plant can live alone and draw its food from the soil. The ramified tubercle which it always bears at its base has ceased little by little to grow, and either dries up or rots. If separated from the plant when still full of life, it continues to live, and one of its buds behaves like that which originally produced the stem from which we have separated it, in fact it gives rise to a second plant. Several plants may thus be raised from the product of the germination of a single seed. The bud which develops into a stem is indifferently terminal or axillary, of the second or third order. No law apparently determines its position, but its composition is always the same: there are always five leaves, four of which reduced to sheaths surround the base of the pseudo-bulb, the highest internode. Each leaf whatever its form bears a bud in its axil. The leaves which surround the pseudo-bulb are alternate and distichous.[1]

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[1] For figures, see the original paper in *Ann. Sci. Nat.*, loc. cit. Seed and germination, pl. 5. Seedling plant and its development, p. 16, figs. 1–9.

SCITAMINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 636.

Fruit and Seed.—The ovary is inferior, three-celled or one-celled by arrest, two cells being small and empty as in Maranta, Stromanthe, Ctenanthe, Saranthe, Ischnosiphon and Thalia ; rarely truly one-celled with three parietal placentas, as in Mantisia, Globba, Guillainia and Hemiorchis, or two-celled (Tapeinochilus). The ovules are solitary and erect from the base in each cell (Heliconia), or indefinite in one to many series on the axile, rarely parietal (Mantisia &c) placentas, horizontal, or ascending, anatropous. The fruit is crowned by the persistent calyx or naked, the whole perianth being deciduous, and with the seed varies considerably in the four well-marked tribes, often separated as distinct Orders, into which the Scitamineæ are divided.

TRIBE I. ZINGIBEREÆ.

The fruit where known is sometimes a loculicidally dehiscent capsule, as in Roscoea, Hedychium, and Costus. The wall of the capsule is often leathery, but sometimes thin, and almost membranous, and then usually bursts irregularly as in Globba and Zingiber. In some genera (Elettaria, Amomum and Alpinia) it is indehiscent and almost baccate. The pericarp is usually smooth. The form of the fruit varies from round to elongated or angular, in Burbidgea it takes the shape of a long pod. The seeds are numerous, more or less spherical, or conical, or angular, with a rounded side towards the pericarp. The testa is smooth and shiny, grey or brownish, sometimes red, more rarely is it wrinkled on the surface. It bounds a starchy perisperm surrounding an albuminous endosperm, inside which is the embryo. The latter, however, abuts on the testa at the hilum, where the continuity of the seed-coat is interrupted by a stopper. Tschirch [1] has recently shown that absorbent organs corresponding to the scutellum of Grass seeds and the 'suckers' of Palm seeds are present in all the tribes of Scitamineæ. In Elettaria speciosa, the stopper in the ripe seed is only united to the testa by a delicate ligament. The embryo consists of an elongated club-shaped sucker surrounded by the endosperm, and connected by a narrow neck with the embryo proper, which resembles a broad cone with a flat base, and includes a radicle and plumule. The portion of the testa opposite the radicle consists of a lid-like stopper, a structure which Tschirch found general in the Order. The sucker shows no differentiation, and remains in the seed in germination while the neck portion elongates, causing the stopper to be pushed out and the embryo to emerge. The radicle bends downwards and the plumule sheathed by a horn-shaped leaf, the coleoptile or cotyledon, upwards. The young seedling remains united with the internal sucker by a long filiform appendage from the base of the sheath-like cotyledon, the elongated neck of the embryo. This connection is kept up till all the reserve-material is consumed. Other species of Elettaria, e.g. E. Cardamomum as well as the genera Amomum, Alpinia and others, behave quite similarly, the differences lying in the form of the endosperm, the shape of the stopper and the sucker. In Alpinia nutans the latter is bilobed, grasping with one of the lobes a section of the sickle-shaped endosperm, while in Amomum dealbatum the similarly shaped endosperm is penetrated by a wedge-like sucker. Germination is analogous throughout.

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[1] Die Saugorgane der Scitamineen-Samen,' in *Mitth. Math. u. Naturwiss. aus d. Sitz. der k. Preuss. Akad. der Wiss. zu Berlin*, 1890, Heft 2.

TRIBE II. MARANTEÆ.

The fruit is three-celled, with one seed in each cell as in Phrynium, Calathea and others, or one-celled with one seed as in Maranta, Thalia, &c. Sometimes it is indehiscent, sometimes bursts in irregular pieces, but usually shows a valvular dehiscence, which is loculicidal in the three-seeded capsules. Where the fruit is one-seeded it may separate into three equal valves, or one valve may be small compared with the other two, sometimes linear. In Maranta and Stromanthe the valves are about equal in breadth but only one becomes separated, the other two remaining almost or quite coherent.

TRIBE III. CANNEÆ.

The fruit is a three-celled capsule, with its surface warty or beset with weak prickles. The seeds are roundish with a straight embryo lying in the hard, very tough, white perisperm. There is no endosperm. The absorbent organ of Canna is club-shaped, embedded in the perisperm and separated by a plain constriction from the embryo proper. The latter consists of a sheath-like cotyledon surrounding the very well-developed plumule, in which several involute leaves can be distinguished, and a somewhat obliquely placed cone-shaped radicle forming the apex of the whole. There is no stopper in the seed-coat indicating the future point of exit of the radicle, but at the spot towards which this is directed the hard layer of palisade sclerome cells is interrupted by a sickle-shaped opening, where the testa subsequently splits.

The epidermis of the sucker consists of a layer of elongated palisade-cells. The process of germination resembles that of the Zingibereæ. The neck of the embryo elongates considerably, while the vegetative portion emerges from the testa and develops root and shoot system outside. The elongated neck-portion remains attached to the back of the cotyledonary sheath till the sucker has exhausted the nutriment contained in the perisperm.

TRIBE IV. MUSEÆ.

The fruit is here a berry (Musa), sometimes fleshy as in M. Sapientum (the Banana), sometimes dry and almost leathery as in M. Ensete, or a three-celled capsule, dehiscing septicidally in Heliconia into three one-seeded portions, while in Ravenala and Strelitzia it is many-seeded with loculicidal dehiscence. The seed in Musa Ensete has a very large broad hilum, corresponding to an orbicular depression of the seed-coat. The seeds of Strelitzia are surrounded at the base with a bilobed woolly mantle. In Ravenala madagascariensis (the Travellers' tree) a sky-blue, or sometimes red, scutiform aril with fimbriated edges envelops the seed. Endosperm is absent, but a quantity of mealy, white, or yellowish-white perisperm takes its place as a store of reserve-material. In Musa Ensete[1] the sucker has a broad disc-like shape; its epidermis is an absorbent epithelium of palisade-like cells, and in this as well as in its somewhat peripheral position with regard to the reserve-material it resembles the scutellum of Grasses. The whole bluish-green embryo is thus knob-like or rather fungoid in shape, the knob or cap being the sucker and the stalk the embryo proper terminating in the radicle. In germination the radicle elongates, pushes out the stopper in the seed-coat and emerges followed by the well-developed plumule. Connection is kept up with the sucker which remains in the seed, and increases considerably in size until the perisperm is exhausted and the seedling by developing green leaves has become independent.

BROMELIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 657.

Fruit and Seed.—The three-celled ovary is inferior in the tribe Bromelieæ, half inferior in the Pitcairnieæ, and superior in the Puyeæ and Tillandsieæ. The ovules are anatropous and usually very numerous when the fruit becomes capsular, or few when a berry is produced. The curvature is mostly towards the free side, the ovules in the upper part of the ovary being turned upwards (epitropous), those near the base downwards (apotropous), the rest usually apotropous, or turned sideways (pleurotropous). The placentas are often provided with palisade-like mucilage-cells (Æchmea, Portea), and this obtains more or less in all genera with pulpy berries. As in many Monocotyledons, we find in the dividing walls of the ovary-cells, clefts lined with honey-secreting cells, the so-called septal glands.

The fruit is baccate in the Bromelieæ where the ovary is inferior, sometimes almost leathery (Æchmea, Billbergia), in the other tribes it is a capsule. In Ananas (the Pineapple), the axis, bracts and fruits are all fleshy and united into a

[1] Wittmack, 'Musa Ensete,' *Linnæa*, 35, taf. iii.

pseudocarp; the axis is proliferous, growing through and forming at the apex of the whole a tuft of green leaves. The berry is sometimes of a brilliant colour, e.g. red in Lamprococcus fulgens, blue in the monotypic genus Ronnbergia. There is considerable variety in size and shape; the berry may be globose or cylindrical, the size of a small pea, or several inches long. The capsule dehisces septicidally by three valves separating from the apex downwards.

The seeds are usually numerous, fewer where the fruit is baccate, and then usually ovate or lenticular (Bromelia, Billbergia), in capsular fruits lenticular (Dyckia), elongated (Pitcairnia), or linear (Tillandsieæ). The seed-coat is often provided with means of distribution, such as an asymmetrical wing (Dyckia), tuft-like appendages at the apex or both ends (Pitcairnia), or silky hairs as in the Tillandsieæ. These structures usually arise from the outer integument, the hairs also from the funicle.

The seeds contain a large quantity of endosperm, the embryo being small and excentric, sometimes as in Bromelia embedded in the endosperm, but more often lateral as in Grass seeds (cf. Dyckia, Caraguata, Guzmannia). The embryo consists of a radicle, with a frequently well-developed hypocotyl bearing a single cotyledon which sheathes the plumule, while the absorbent organ present in the albuminous Scitamineæ is according to Tschirch developed in Bromeliaceæ in a relatively great variety of ways.[1] Sometimes, as in Caraguata, it forms a structure resembling the scutellum of Grasses, sometimes it is club-shaped, penetrating deeply into the endosperm, as in Guzmannia.

The species of this Order being mostly epiphytes growing on trees, and inhabiting the tropical and subtropical parts of America, their germination has not been much studied.

According to Klebs,[2] germination takes place in Acanthostachys strobilacea in a manner common to a great number of Monocotyledons. The primary root projects first and grows rapidly downwards, provided in this case, except at the apex, with a thick covering of long hairs. One end of the cotyledon remains in the seed, forming the absorbent organ; the other emerges and forms a short sheath. The second leaf emerges from the top of this sheath.

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[1] *Loc. cit.* p. 94.

[2] *Beiträge zur Morphologie u. Biologie der Keimung*, p. 565, fig. 11.

IRIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 681.

Fruit and Seed.—The ovary is inferior and three-celled with axile placentas, or very rarely, as in Hermodactylus, one-celled with three parietal placentas. The ovules are usually numerous in each cell, rarely reduced to one or two; they are anatropous. The fruit is a globose, obovoid, oblong or rarely linear capsule, with a loculicidal dehiscence. Sometimes, sa in Tigridia, Rigidella, and Herbertia, the top protrudes beyond the perianth-tube, leaving a free operculum at the bottom of which the dehiscence stops at any rate for a time. The seeds are few or numerous, superposed in two series, rarely solitary in each cell with short, often very short funicles, and a strophiole. They vary much in shape, and may be globose or generally angular by mutual pressure, but sometimes flattened. Variations occur even in the same genus, thus Gladiolus segetum has globose seeds, while in the very closely allied G. byzantinus they are flat. The testa is membranous or slightly thickened and spongy. The endosperm is horny and fills the seed. The small embryo is completely enclosed in the endosperm at a little distance from the hilum.

Germination.—We may distinguish three types characterised by differences in form and behaviour of the cotyledon. The first, according to Klebs,[1] is represented by Iris Pseudacorus and Ixia crateroides. Here, as in the two following types, the primary root is the first to emerge from the seedling, and grows rapidly downwards. The hypocotyl is very slightly developed, but the lower end of the cotyledon elongates at an early period of germination drawing out of the seed the plumule which is enclosed in its sheathing base. The other end remains in the seed. The cotyledon thus consists of a short lower sheathing portion, from which the second leaf soon breaks in the form of a long, slender, wedge-like sheath with a green tip, and an upper portion perfectly continuous with it in connection with the seed, its apex remaining embedded in the endosperm. This is the simplest type. We have represented, in what is evidently a single structure, the cotyledon, first an absorbent organ to absorb the endosperm contained in the seed; secondly a means of connection between this and the seedling; and thirdly a protecting sheath for the developing plumule.

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[1] *Loc. cit.* pp. 564–5, fig. 11.

In the second type, the more general one in the Order, the cotyledon shows greater differentiation of structure, the parts which perform the three functions being quite distinct from each other. The lower portion still forms the protecting sheath, but is much longer than in the first type. Attached to it, either at the apex, or some varying distance below, is a long thread-like connective, the other end of which is swollen into a more or less club-shaped absorbent organ, buried in the endosperm of the seed. As in the first type the whole of the cotyledon remains beneath the ground. This obtains, according to Irmisch, in Iris sibirica and I. Xiphion,[1] and probably in many other species, also in Gladiolus communis, palustris, and other species. Alefeld[2] says a Moræa germinated just like Iris.

The third type differs in that the long thread-like cotyledon after exhausting the endosperm gets quite free from the seed and appears above the soil as the first green foliage-leaf. Hence the striking differentiation of structure of the last type is absent. The hypocotyl, as general in the Order, is undeveloped. Germination begins with the elongation of the lower part of the cotyledon, which pushes the root before it, and follows it, both growing quickly, a short distance downwards in the soil. Rapid growth at the bend causes the cotyledon to form a sharp knee, and each of the two limbs continuing to grow, this is pushed upwards, thus breaking the soil in the manner of the hypocotyl of many Dicotyledons.

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[1] *Abhandl. Nat. Ver. Sachs. u. Thuring. Halle*, i. p. 139.

[2] Alefeld, *Bot. Zeit.*, 1864, p. 246.

When the endosperm is exhausted it draws itself quite out of the withering seed, the bend becomes straightened, and the whole cotyledon then appears above the soil as the first green foliage-leaf. From its sheathing base appears the second. This method occurs in Sisyrinchium. Velenovsky [1] describes the same in seedlings of Iris sp.

Gladiolus communis, *L.*

Primary root tapering downwards, branching slightly.

Hypocotyl undeveloped.

Cotyledon subterranean, of three parts, an absorbent organ remaining in the seed, connected by a long thread-like part with the top of the sheath, the lower end of which is continuous with the base of the root. The latter portion forms a long sheathing tube, cleft on the ventral side, with a rounded, somewhat truncated apex to the back of which the connective is attached.

The first foliage leaf emerges from the sheath. It is broad and compressed, and its long, narrowly cleft sheath includes the following leaf. During the first vegetative period the internode between the insertion of the first foliage-leaf and that of the sheathing-leaf which follows it and encloses next year's leaf-structure, swells to a tuber. This is at first covered by the thin sheath of the cotyledon (the connective has long since died away), but this soon perishes, and the tuber is protected by a dry envelope formed from the sheath of the succeeding foliage-leaf. The terminal bud by which the plant will resume growth next season occupies the apex of the tuber. The primary root perishes towards the close of the first period, a few fleshy adventitious roots break out, close to it, from the short axis beneath the tuber, but as these are often wanting they do not appear to be essential for the nourishment of the plant. Up to time of flowering the plants, which, save for increase in size and number of the leaf-structures, do not alter essentially in the next year, continue to grow by means of the terminal bud, while axillary buds also appear.

The leaves of the adult plant are long, ensiform, sheathing at the base, lanceolate, acute, and entire with several prominent nerves.

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[1] *Flora*, 1887, p. 454.

AMARYLLIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 711.

Fruit and Seed.—The ovary is inferior and three-celled with axile placentation, very rarely one-celled with parietal placentas. The ovules are numerous in each cell and superposed in two ranks, rarely reduced to one or two, and always anatropous. The fruit is capsular or succulent, undivided or trilobed, variously dehiscent or indehiscent. The seeds are globose, or angled, or flattened by mutual pressure, and have a membranous or thickened, often black testa. Endosperm is copious and fleshy or rarely horny. The embryo is small, rarely half as long as the endosperm. Important exceptions to the above characters occur in Calostemma which has by abortion a one-celled ovary with one or two ovules, and in Leontochir which has a triangular, one-celled ovary with three parietal placentas.

The fruit of Crinum is capsular and irregularly subglobose according to the number of seeds it contains. The seeds are very large and irregularly compressed with a thick testa. In some cases at least they commence to germinate soon after they are mature and have dropped on the ground, or even when kept in a drawer or other dry place. This they are able to do by reason of the large quantity of endosperm and the moisture they contain. The seeds in the capsule of Nerine are few or solitary and greenish. The capsule generally if not always bursts open, exposing the seeds long before they are ripe; after thus dehiscing the valves do not seem to increase in size.

Seedlings.—The solitary cotyledon is frequently subterranean, and in other cases where it rises above ground, it carries up the seed with it as shown by Agave Wislizeni (fig. 680). The hypocotyl in this case is undeveloped, the primary root is stout and fleshy, and adventitious roots are soon given off close to the base of the cotyledon.

The latter is subulate, elongated, dilated and sheathing at the base, and 3·3–6 cm. long. The first leaf emerges from the sheath of the cotyledon, is sessile, lanceolate, acuminate, and minutely spiny at the margin.

Agave Wislizeni, *Engelm.* (fig. 680).

Primary root stout, tapering downwards, colourless, soon giving off adventitious roots close to the base of the cotyledon.

Hypocotyl undeveloped.

Cotyledon succulent, subulate, elongated, much tapered to the apex, and carrying up with it the rotund-obovate, thin and much compressed black testa, much dilated and sheathing at the base, above which it is split to allow the plumule to emerge, terete, glabrous, deep green, 3·3–6 cm. long, 2·5–3 mm. in diameter above the basal sheath.

Stem succulent, very short, with undeveloped internodes, except in the flowering stem.

Leaves simple, radical, alternate, exstipulate, sessile, succulent, glabrous, deep glaucous-green on both surfaces, concave in vernation or convolute, spiny at the margin at least in the seedling stage, without discernible venation.

No. 1. Lanceolate, acuminate, deep glaucous-green with a hyaline minutely spiny margin, emerging from the basal sheath of the cotyledon.

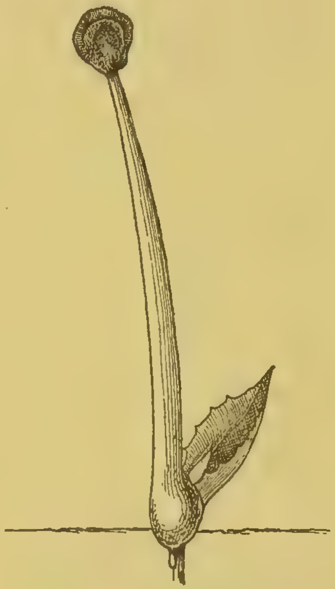

Fig. 680.—*Agave Wislizeni.* Nat. size.

DIOSCOREACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 741.

Fruit and Seed.—The plants of this Order have monœcious or diœcious and only exceptionally or abnormally hermaphrodite flowers. The ovary is inferior, and three-celled with axile placentation and two ovules in each cavity, suspended from near the apex of the placentas and anatropous or almost amphitropous. The fruit is capsular and three-valved or baccate and indehiscent; when capsular the seeds are compressed, and when baccate they are globose. In both cases these forms relate to the method of distribution. The endosperm is fleshy or almost cartilaginous. The embryo is small and slightly distant from the hilum.

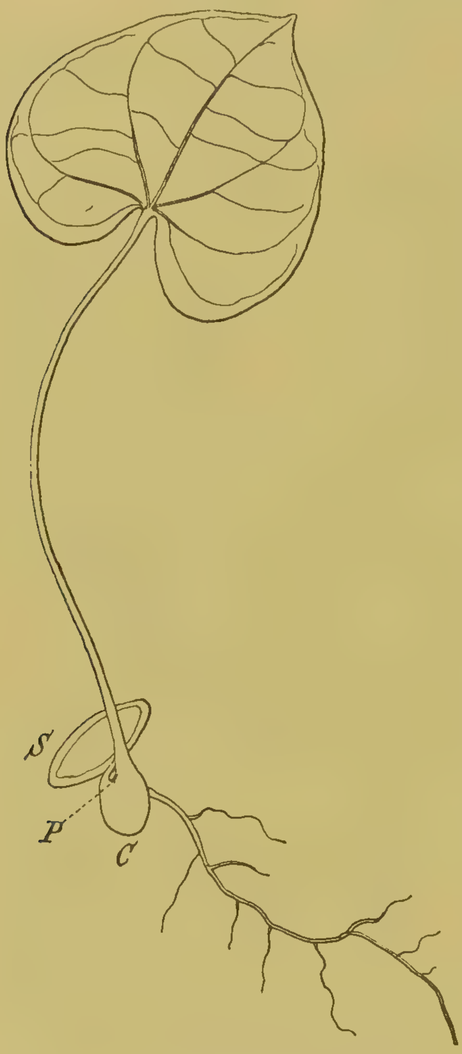

Fig. 681.—*Testudinaria elephantipes.* *S*, seed; *P*, plumule; *C*, fleshy tuber from hypocotyl. Nat. size.

The seed of Testudinaria elephantipes is elliptic, very much compressed or flattened, and winged.

Seedling. — Testudinaria elephantipes (fig. 681) may be given as a type of the Order. The cotyledon remains in the seed after germination till it decays. The hypocotyl is subterranean, very short, and develops in the early stages of the seedling into an ovoid, fleshy tuber. The first leaf is comparatively large, cordate and somewhat reticulate with five strong nerves radiating from the base, and becoming curved at their tips. The persistent rootstock or stem ultimately becomes a woody, flattened, globose or conical mass, rather deeply fissured in a reticulate manner, presenting the appearance of the shell of a tortoise.

Testudinaria elephantipes, *Burch.* (fig. 681).

Primary root elongated, flexuose, stout, with fibrous lateral rootlets.

Hypocotyl very short, subterranean, thickening into a fleshy, ovate tuber, generally if not always rootless during the earlier stages of growth.

Cotyledon subterranean, remaining in the seed and fusing with or closely adhering to the endosperm, where it remains till decay.

Stem undeveloped in the early stages of the seedling.

Leaves simple, entire, radical or cauline, alternate, exstipulate, petiolate, glabrous, reticulated, with the principal nerves radiating from the base and becoming incurved upwards.

No. 1. Cordate, subacutely cuspidate, with five strong leading nerves radiating from the base, and two weaker branches from the basal pair.

LILIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 748.

Fruit and Seed.—The ovary is superior and generally three-celled, with axile placentation, sometimes one-celled with three parietal placentas, very rarely two- to four- to many-celled. The ovules are twin in each cell and collateral or numerous and arranged in a double series, rarely solitary; they are anatropous, semianatropous, or in some genera orthotropous. The fruit is baccate and indehiscent, or capsular; in some cases the three component carpels are separated almost to the base. The seeds vary, being flattened, angular or globose, and with or without an arilloid. The testa also varies in thickness and texture, and is sometimes developed into a wing. Endosperm is plentiful and fleshy, cartilaginous or horny. The embryo is very small and globular, or elongated and straight or curved, with the radicle close to the hilum, or sometimes distant from it. The ovules are exceptional in Smilax, Ruscus, and some of their allies in being orthotropous.

Instances of globose or subglobose seeds are met with in Ruscus, Asparagus, Polygonatum, Convallaria, Hyacinthus, and others. The seeds of Tulipa, Lilium, Fritillaria, Urginea and others are flattened or much compressed. Angular seeds are met with in Allium, Galtonia, Paradisia, Asphodelus, Asphodeline, Anthericum, and others.

Seedlings.—The cotyledon in this Order is generally, if not always, aerial, and carries the seed up with it during germination. The testa is ultimately dropped, generally by the decay of the tip of the cotyledon. The hypocotyl of Bowiea volubilis (fig. 682) is undeveloped; and the primary root soon superseded by fleshy, adventitious roots. The cotyledon is terete and solid except at the base, which is hollow and sheaths the plumule; it becomes very much inflated there, constituting the first tunic of the bulb. It varies greatly in length, from 10–23 cm. in different seedlings. The first leaf resembles the cotyledon except in being very much shorter. The leaves of the adult plant arise from the bulb and are deciduous; those of the much branched and twining flower stem are reduced to bracts. On small bulbs the radical leaf is solitary, semi-terete, and channelled on the upper surface.

The primary root of a species of Tulipa (fig. 683) from Afghanistan is short, fleshy, unbranched, and soon dies away. The hypocotyl is undeveloped, and the cotyledon is terete, thickest in the middle, tapering each way, and carries the testa for a time at its apex. It soon becomes gibbous at the base, and then develops into a blunt tube which penetrates the soil, carrying the plumule down with it at the bottom of the tube, and both together constitute the first bulb. The object of this peculiar growth is to bury the bulb at a sufficient depth in the soil. The process is repeated in succeeding years when fresh growth is being made, in order to carry it still further beneath the soil as it gains strength. No true leaves are developed during the first year of the plant from seed.

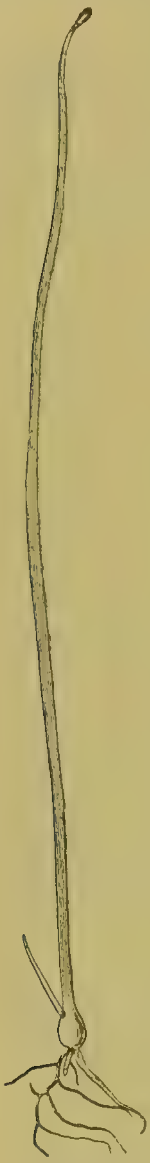

Fig. 682. *Bowiea volubilis.* Half nat. size.

Bowiea volubilis, *Harv.* (fig. 682).

Primary root tapering downwards, transversely wrinkled flexuose, with flexuose lateral rootlets, soon superseded by long fleshy, colourless and, at least in the early stages, unbranched adventitious roots.

Hypocotyl undeveloped.

Cotyledon erect, terete, solid, dilated at the base forming the first bulb, including the plumule, tapering gradually upwards to a slender point, bearing the small black shining obovoid testa, which it retains until the tip withers and allows the testa to fall off, glabrous, deep shining green, dotted with minute colourless points, 10–23 cm. long, 1·5–2·5 mm. thick.

Stem excessively short in the seedling stage, with undeveloped internodes, ultimately producing a bulb 10–15 cm. or more in diameter. Bulb of cotyledon 4·5–6 mm. in diameter. The old bulb consists of a few closely adpressed, green and fleshy tunics or sheaths.

Leaves simple, entire, radical and cauline, alternate, exstipulate, sessile, glabrous, soon falling away or deciduous.

No. 1. Radical, erect, terete, bright green, pushed out from the base of the cotyledon, and similar to it, 1·8 cm. or more long. Leaves of the flowering stem numerous, small and scale-like, subtending the numerous branches and branchlets.

Tulipa sp. (fig. 683).

Seed obovate, very much flattened vertically, thin, winged, glabrous, brown, with a very small micropyle even after germination and not splitting, 8–9 mm. long, 6·5–7·5 mm. wide.

Primary root fleshy or succulent, brittle, rather thick and tapering very little, apparently never branching, and soon dying away, straight or flexuose, whitish or dirty yellow, with few or no root-hairs.

Hypocotyl undeveloped.

Cotyledon terete, solid, elongated, thickest in the middle and tapering to the base, but more so to the apex, which is produced into a very slender point usually carrying the testa; deep subglaucous-green, glabrous, withering early at the tip, allowing the testa to drop, 7–8·5 cm. long; basal part becoming gibbous and hollow, forming a very blunt point which pushes its way downwards into the soil carrying with it the plumule, and finally ending in a blunt point with a few undeveloped root-like

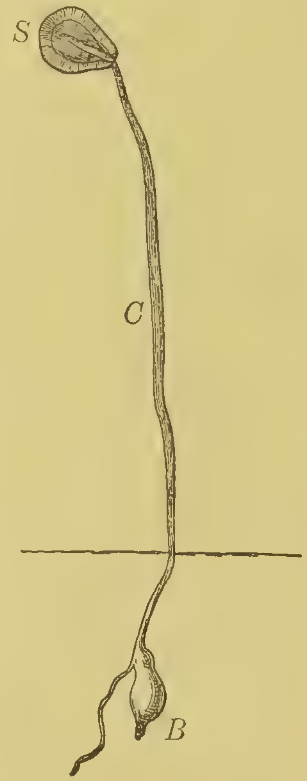

Fig. 683.—*Tulipa* sp. Nat. size. *S*, seed; *C*, cotyledon; *B*, primary bulb.

protuberances; above this it swells, forming the first bulb, a small ovoid body containing a fleshy scale-leaf.

Leaves none the first year.

PALMÆ.

Benth. et Hook. *Gen. Pl.* iii. 870.

Fruit and Seed.—The ovary is free, ovoid, oblong or globose, rudimentary or absent in male flowers, more or less perfectly three- rarely four- to seven-celled, entire or trilobed, or formed of three more or less distinct carpels. The ovules are solitary in each carpel and erect or fixed by a broad base to the interior angle, subhorizontal or pendulous, anatropous or semi-anatropous. Fruit dry, baccate or drupaceous, with the terminal excentric, lateral or basilar remains of the style or stigmas, one- rarely two- to many-celled and -seeded, rarely consisting of one to three distinct one-seeded carpels. Exocarp frequently fibrous, endocarp membranous, crustaceous, woody or stony, smooth internally or wrinkled and marked by the branching raphe, having in the Cocoineæ three symmetrical pits, two of which correspond to barren cells. Seeds conforming to the endocarp, and free or adherent to it, with a basilar or lateral hilum; testa closely adherent to the albumen, raphe short or elongated, often adherent to the endocarp, sometimes surrounding the seed with numerous branches varying in direction and often branching again or reticulate. Endosperm horny or cartilaginous, sometimes oily, solid or hollow or indented at the apex or side, often ruminate. Embryo small, conical or cylindrical, sunk in the periphery of the endosperm, usually at the hilum next the dorsal side, rarely lateral or apical.

Germination takes place according to a very prevalent monocotyledonous type. The radicle, pushing aside the operculum in the testa, emerges first, and penetrates the soil usually to a considerable depth, becoming both long and strong. The very short hypocotyl is thus drawn out of the seed, bearing the rapidly elongating sheath of the cotyledon which encloses the plumule. The other end of the cotyledon remains in the seed, forming a sucker to absorb the endosperm; a narrow neck connects it with the sheath portion, from which the first green leaf soon protrudes.

AROIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 955.

Fruit and Seed.—The ovaries are superior and numerous on each inflorescence, globose, ovoid, oblong or flask-shaped, one- to many-celled, and arranged spirally on a fleshy axis or spadix, or in parallel and longitudinal rows in the case of Spathicarpa and Spathantheum. The ovules are solitary or several in each cell, basal, parietal, axile or inserted on the edges of half-intruded septa, or pendulous from the apex of the cell and orthotropous, anatropous, or half-anatropous, rarely campylotropous or amphitropous. The fruit is baccate or membranous, indehiscent or dehiscing tardily. The seeds are small or large with a variable testa and a copious, fleshy, rarely farinaceous endosperm, or may be scanty and sometimes absent. The embryo is elongated, rarely small, and horseshoe-shaped where endosperm is absent.

Seedling.—In Anthurium margaritaceum the cotyledon is subterranean, with an extremely short petiole or none at all, and remains in the seed till it decays. The primary root is soon superseded by strong adventitious roots from the stem at the base of the leaves. The hypocotyl is undeveloped; and the first internode of the stem is 5 mm. long, but subterranean. The first three leaves are ovate-elliptic and trinerved.

Anthurium margaritaceum, *Baker.*

Seeds small, 2 mm. long by 1·25 mm. wide.

Primary root soon superseded by long and fleshy adventitious roots.

Cotyledon subterranean, remaining in the seed till it decays.

Stem exceedingly short, inconspicuous, pale green or colourless, glabrous, extending 5 mm. below ground.

Leaves simple, entire, radical, alternate with very short internodes, acute, ovate-elliptic, glabrous, bright green, with petioles slightly longer than the leaf, exstipulate; midrib and two lateral nerves meeting at the apex with subsidiary veins between given off from the midrib.

ALISMACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1003.

Fruit and Seed.—The ovary consists of six free carpels, or more rarely three, arranged in one or many series on the receptacle; sometimes they are connate at the base and one-celled. The ovules are solitary in each cell, or twin and superposed, or numerous and inserted on the interior angle; very seldom are they solitary and basal; in the tribe Butomeæ they are very numerous and inserted on reticulately branched placentas all over the walls. They vary greatly in being anatropous, half-anatropous, amphitropous, or campylotropous with an inferior micropyle. The fruit consists of free carpels, or they are united at the base and dehiscent at the ventral suture or indehiscent, very seldom circumscissile at the base. The seeds are ovoid, oblong, or compressed, small or minute, and exalbuminous with a variable testa. The embryo is conduplicately horseshoe-shaped, often thickened at the radicle, very rarely straight, with the plumule hidden at the base of the cotyledon.

Seedling.—Owing to the absence of endosperm in the seeds, the cotyledon in this Order is probably always aerial or aquatic. Alisma Plantago (fig. 684) may be given as a type. The peculiarly thickened hypocotyl so frequent in the Order is noticeable even from the first stages of germination. It produces numerous root-hairs from the edge of the thickened extremity, fixing the seedling in the soil or mud. The radicle itself does not begin to elongate till five or six days after germination. It is devoid of root-hairs for some time, but twelve days after germination they are copious. Adventitious roots commence to be given off from the first node about this time. The cotyledon is subulate-linear or filiform, and sheathes

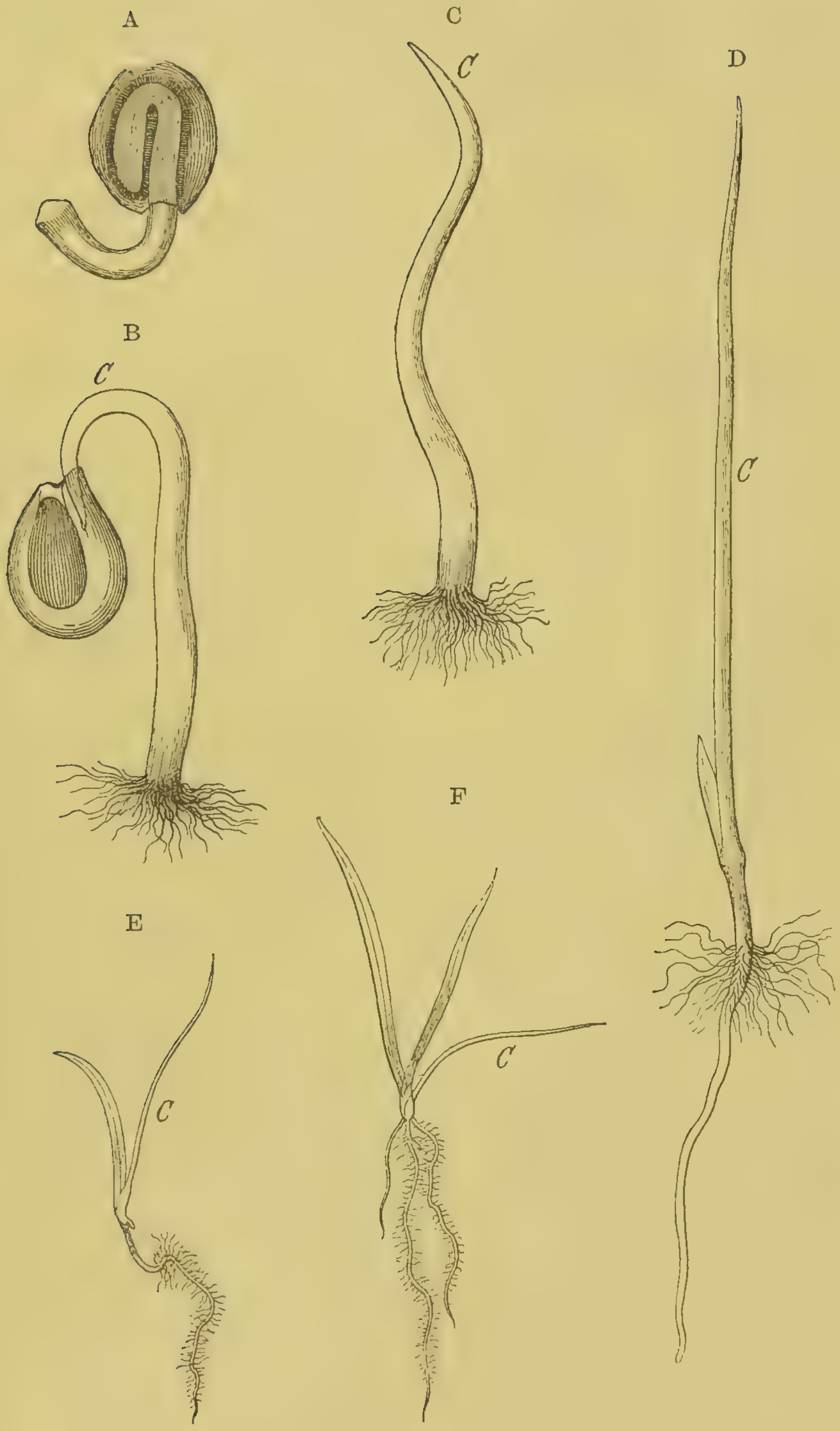

FIG. 684.—*Alisma Plantago*.
A, B, and C, ×8: D, × 4: E, nat. size: F, nat. size: *C*, cotyledon

the plumule by its base. The first two leaves are linear, acuminate, one-nerved and Grass-like. The ultimate ones are oblong-elliptic and comparatively broad.

The primary leaves are often, if not always, relatively very narrow, and the ultimate ones in several genera are broad, oblong, elliptic, oval or sagittate. Those of Sagittaria montevidensis are sometimes eighteen to twenty-four inches wide and proportionately long.

Alisma Plantago, *L.*

Germination (fig. 684).

Seeds sown in a greenhouse, in soil sunk in water, germinated in three days.

The carpels are cuneate, or rather like the segments of an orange, and the seed lies in the interior so that the radicle of the curved embryo occupies the outer and thicker part of the carpel. The radicle being much the thicker part of the embryo requires this accommodation.

The hypocotyl first emerges, and ends very bluntly or even truncately with a thickened margin around the tip (fig. 684, A).

Three days after germination (fig. 684, B) the thickened margin at the base of the hypocotyl gives out numerous root-hairs which fix the plantlet in the soil. The place from whence the plumule should emerge is dimly visible at the base of the slender cotyledon. The carpel or achene is now suspended at the tip of the cotyledon. Hypocotyl very short. Neither the radicle nor the lateral adventitious roots are yet visible.

Four days after germination (fig. 684, C) the cotyledon rises up, freed from the achene, but is still slightly twisted at the end.

Seven days after germination (fig. 684, D) the cotyledon becomes much elongated, narrowly subulate or filiform, tapering slightly upwards and straight. The root-hairs are still copious at the base of the short hypocotyl, and the primary root has become considerably elongated. The plumule is also considerably advanced.

Twelve days after germination (fig. 684, E) the cotyledon has not altered. First leaf linear, acuminate, thin, membranous, showing a distinct midrib. An adventitious rootlet is seen just pushing from the first node, above the hypocotyl. Primary root elongated and furnished with root-hairs nearly to the tip.

Nineteen days after germination (fig. 684, F) the cotyledon is still unaltered. First and second leaves linear, acuminate, with a distinct midrib, sheathed at the base by the cotyledon. Primary root elongated and furnished with root-hairs. Adventitious roots also from the first node well furnished with root-hairs.

CYPERACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1037.

Fruit and Seed.—The ovary is entire, erect and sessile in the centre of the flower, or sometimes placed on a short stalk which may be thickened or expanded to form a disc. It is one-celled and contains a solitary anatropous ovule, erect from the base. The fruit is small, covered by the glume or protruded beyond it, nut-like and indehiscent; when the style is bifid, it is more or less flattened or biconvex, and with a trifid style obscurely or distinctly trigonous. The pericarp is crustaceous and hardened or sometimes subdrupaceous, the exocarp thin or suberously thickened, the endocarp hard. The seed is erect from the base of the fruit, free (? always) from the pericarp, and has a thin testa. The small embryo is lenticular, globose or ovoid and situated within the base of the copious farinaceous or fleshy endosperm.

Seedling.—Poiteau[1] in 1808 recognised that the germination of the Cyperaceæ differed from that of Gramineæ, resembling that of Palms and Liliaceæ, while Klebs in his recent memoir[2] separates it as a distinct monocotyledonous type. Unlike that of Grasses, the germination in this Order has been little investigated. Mirbel[3] describes and figures that of Carex maxima, and Richard[4] that of Scirpus supinus; but beyond this we have little information on the subject till Klebs' memoir.

According to the last author the process is very uniform in the different genera and species investigated (Scirpus lacustris,

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[1] *Ann. Mus. d'Hist. Nat.* xiii. Paris, 1809.

[2] 'Beiträge zur Morphologie u. Biologie der Keimung,' in Pfeffer's *Untersuch. aus d. Bot. Inst. Tübingen*, i. p. 571.

[3] *Ann. Mus. d'Hist. Nat.* xvi. p. 437 (Pl. i.) Paris, 1810.

[4] *Ibid.* xvii. pp. 228–9 (Pl. v. fig. 17). Paris, 1811.

Cyperus Iria, C. Papyrus, Isolepis Savii, Carex caucasica, C. lagopina, and Kobresia caricina). He points out that the structure of the embryo is somewhat different from that of the Grass-embryo, connecting the latter with the typical liliaceous type. The lower end is always occupied by the radicle without any marked root-sheath, the upper by the cotyledon. The Cyperaceæ agree with the Grasses in the distinct development of the cotyledonary sheath, which encloses the clearly indicated first leaf. In germination the cotyledon alone at first grows. The sheath elongates, breaks through its coverings, and bends geotropically upwards.[1] The middle portion of the cotyledon then grows rapidly, and pulls the main root out of the seed. Before the appearance of the root, a circlet of long hairs is developed at the base of the cotyledonary sheath, probably on the portion corresponding to the hypocotyl which does not develop. The hairs take the place of the root in the early stages. The primary root gradually develops while the first leaf appears from the sheath. Ultimately the primary root elongates considerably, the first adventitious root breaks from the base of the cotyledonary sheath, and other leaves succeed the first. The end of the cotyledon which remains in the seed swells until, after absorbing all the endosperm, it almost fills the interior.

GRAMINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1074.

Fruit and Seed.—The ovary is sessile or shortly stalked, erect, entire or sub-bidentate at the foot of the styles. It is one-celled and contains one ascending anatropous ovule, fixed near the base or laterally, and often separable with difficulty from the ovary. The fruit is termed a caryopsis, and is indehiscent, usually small, and included in the glume and pale with a fragment of the rhachilla, together with which or the whole spikelet it drops off; it rarely protrudes from the glume or falls separately. The pericarp is usually very thin, closely adnate to the seed with a mark over the hilum, rarely loose, membranous, or in some members of the tribe Bambuseæ, hard and crustaceous or very thick and fleshy. The seed-coat is adnate to, and not to be distinguished from the pericarp, or is free from the latter and very thin and adnate to the endosperm. The endosperm is copious, and farinaceous or rarely fleshy. The embryo is small, globose or depressed, often minute and situated at the base of the endosperm. It shows a very characteristic distinction of parts, and often a high development. The most characteristic is the cotyledon, which consists of two clearly separated portions: the *scutellum* or absorbent organ which remains in the seed in germination, first causing the solution of the nutrient endosperm and then absorbing it; and the sheathing portion which protects the plumule and in germination penetrates the soil and appears above the earth still enveloping the first green leaf. This view of the morphology of the cotyledon was hinted at by Gaertner[1] and subsequently elaborated and strongly insisted on by Van Tieghem[2] from the anatomy of the organs especially the course of the vascular bundles. A similar arrangement has lately been described by Tschirch in the Scitamineæ (see *ante*, p. 566). The radicle is enclosed in the root-sheath (coleorhiza); several lateral rootlets are often indicated.

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[1] Well shown by Mirbel in *Scirpus romanus* in *Eléments de Physiologie Végétale*, p. 59, fig. 4.

Seedling.—The germination of Grasses has been carefully investigated by many workers from Mirbel, Poiteau and Richard onwards. It differs from that of Cyperaceæ by the radicle, and not the cotyledon, first emerging and growing rapidly downwards. The root-sheath is first slightly protruded from the seed, but is soon broken by the root which rapidly elongates, and is usually closely covered with hairs, which are also often found on the free surface of the root-sheath. The cotyledonary sheath grows upwards, penetrates the testa, pericarp, and the glume when present, and makes its way through the soil as a sharp wedge, while the scutellum slowly absorbs the endosperm. In some cases, as in Sorghum, Panicum, and Eleusine, intercalary growth occurs in the tissue (? hypocotyledonary) at the base of the sheath separating it by a narrow limb from the scutellum.

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[1] *De Fructibus*, &c. 1788, i. p. cxlix.

[2] 'Observations anatomiques sur le Cotylédon des Graminées,' *Ann. Sci. Nat.* ser. v. tom. xv. (1892), p. 236.

Growth of the primary root is always limited; sooner or later numerous adventitious roots break through and take its place.

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SCHLEIDEN's original drawings [1] include seedling of *Pistia commutata*, and a fine series illustrating germination of *P. Stratiotes*.

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CAPRIFOLIACEÆ.

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ELATINEÆ.

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LOGANIACEÆ.

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MAGNOLIACEÆ.

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Pedalineæ.

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PHILYDRACEÆ.

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PHYTOLACCACEÆ.

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BAILLON, *l. c.* iii. p. 469, figures seed of *Piper nigrum.*

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